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REPORT OF THE INTERNATIONAL JOINT COMMISSION, UNITED STATES AND CANADA, ON THE POLLUTION OF BOUNDARY WATERS

International Joint Commission-
United States and Canada

1951

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Report

OF THE

INTERNATIONAL JOINT COMMISSION

UNITED STATES AND CANADA

ON THE

Pollution Of Boundary Waters

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INTERNATIONAL JOINT COMMISSION

UNITED STATES	CANADA
A. O. STANLEY, Chairman	A. G. L. McNAUGHTON, Chairman
ROGER B. McWHORTER	GEORGE SPENCE
EUGENE W. WEBER	J. LUCIEN DANSEREAU
Jesse B. Ellis, *Secretary*	E. M. Sutherland, *Secretary*

Counsel

On behalf of *Government of United States*	*On behalf of* *Government of Canada*
William R. Vallance	Kenneth J. Burbridge

LETTER OF TRANSMITTAL

The following letter was sent to the Secretary of State, Washington, D. C., by the secretary of the United States Section of the International Joint Commission and to the Secretary of State for External Affairs, Ottawa, Canada, by the secretary of the Canadian Section of the International Joint Commission:

October 11, 1950.

Sir,

I have the honor to transmit a copy of Report of the International Joint Commission to the Governments of Canada and the United States in the matter of the pollution of boundary waters dated October 11, 1950.

Under the reference of April 1, 1946 the Commission was directed to investigate and report upon the waters of the St. Clair River, Lake St. Clair and the Detroit River; under date of October 2, 1946, the reference was extended to include the waters of the St. Marys River from Lake Superior to Lake Huron; and on April 2, 1948, the Commission was directed to report on the waters of the Niagara River from Lake Erie to Lake Ontario. Copies of the Reports of the Board of Technical Advisers, covering these two sections of the investigation are enclosed.

I have the honor to be,
Sir,
Your obedient servant,

JESSE B. ELLIS,
Secretary, United States Section

E. M. SUTHERLAND,
Secretary, Canadian Section

United States

Canada

DETROIT RIVER

Large populations and great industries have developed along the shores of these boundary waters.

United States
Canada

UPPER ST. CLAIR RIVER

These boundary waters are vitally important to the health, recreation, and national economy of both countries.

Canada
United States

ST. MARYS RIVER

The welfare of the people of both countries is influenced in no small measure by the maintenance of these waters free from objectionable pollution.

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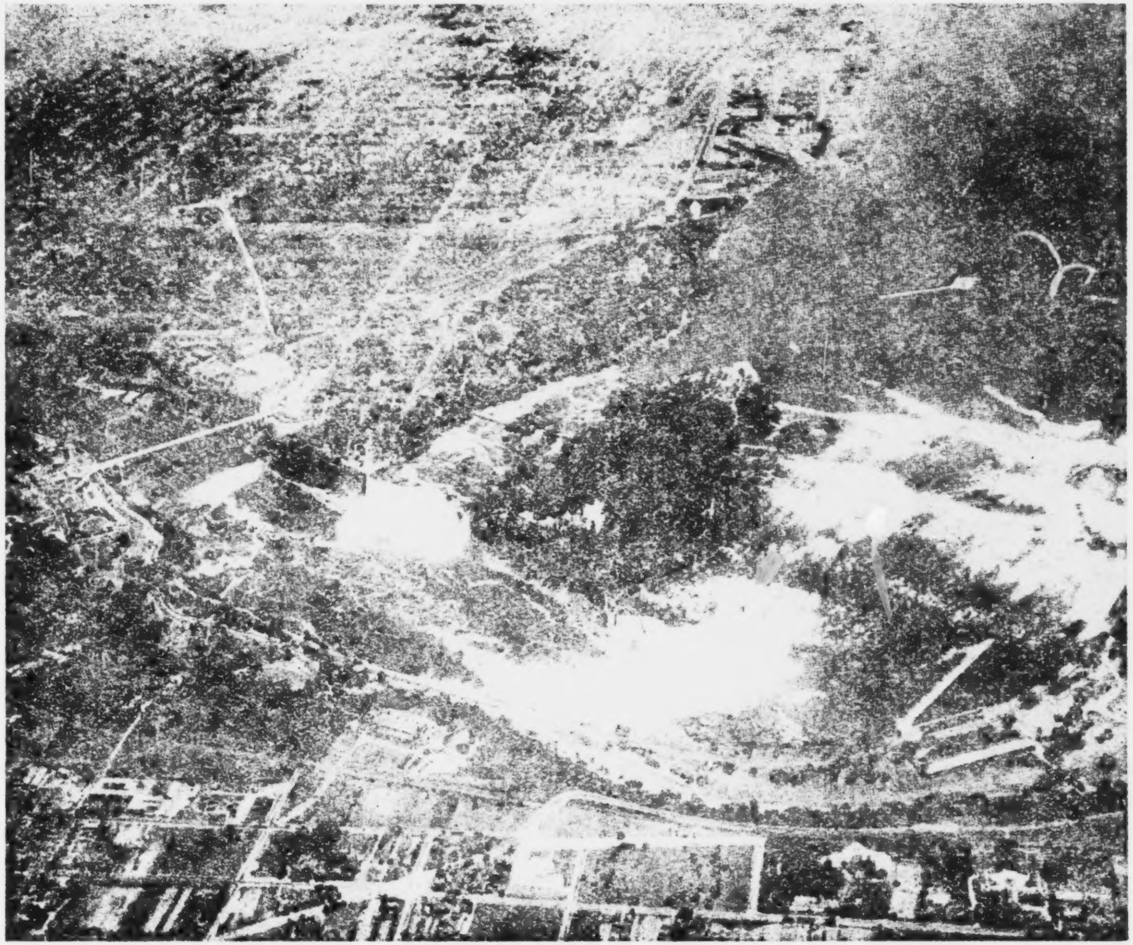
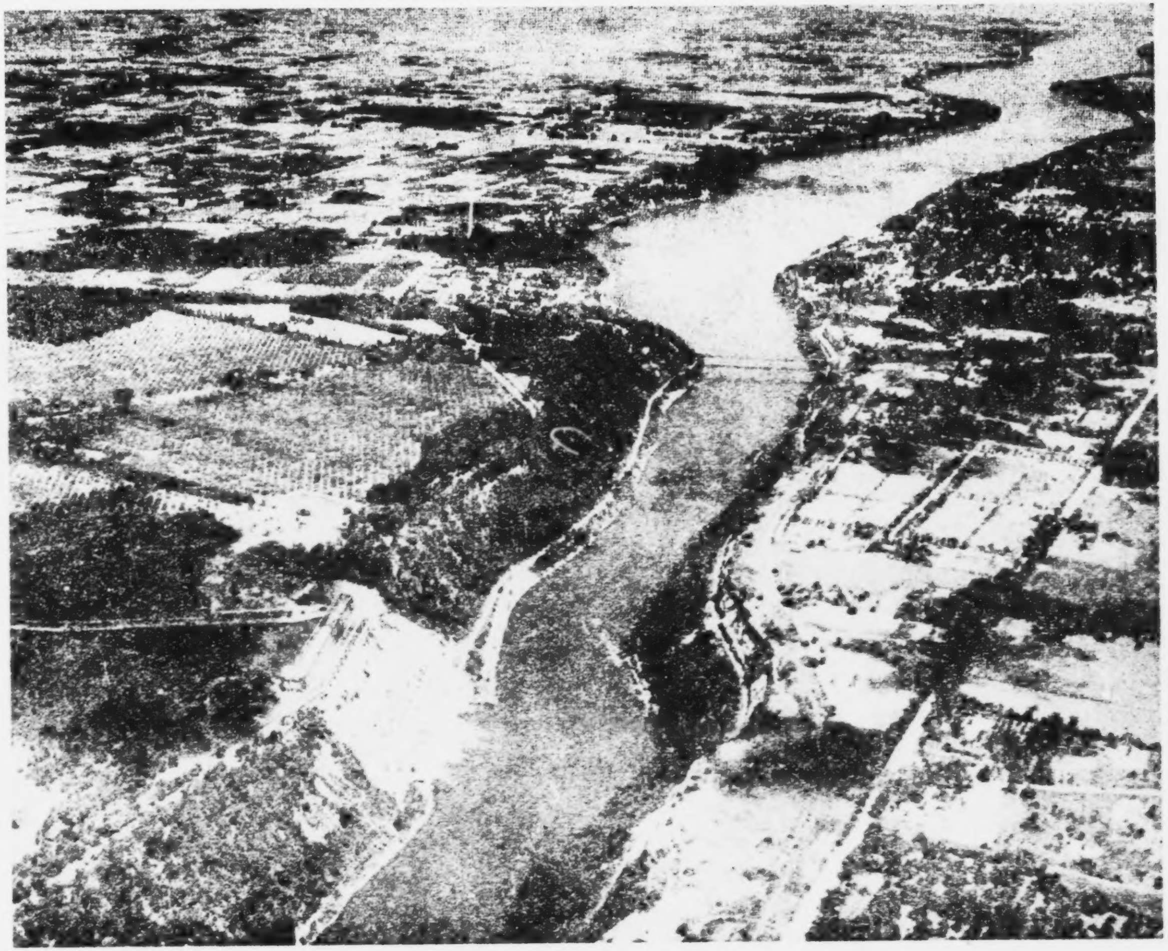


NIAGARA FALLS

The Niagara River, famed in history, is noted for scenic beauty, hydro-electric power, and industrial development.


Canada
United States

LOWER NIAGARA RIVER

Looking downstream, showing the Queenstown Power Plant, Lewiston Bridge and the River outlet into Lake Ontario in the distance.

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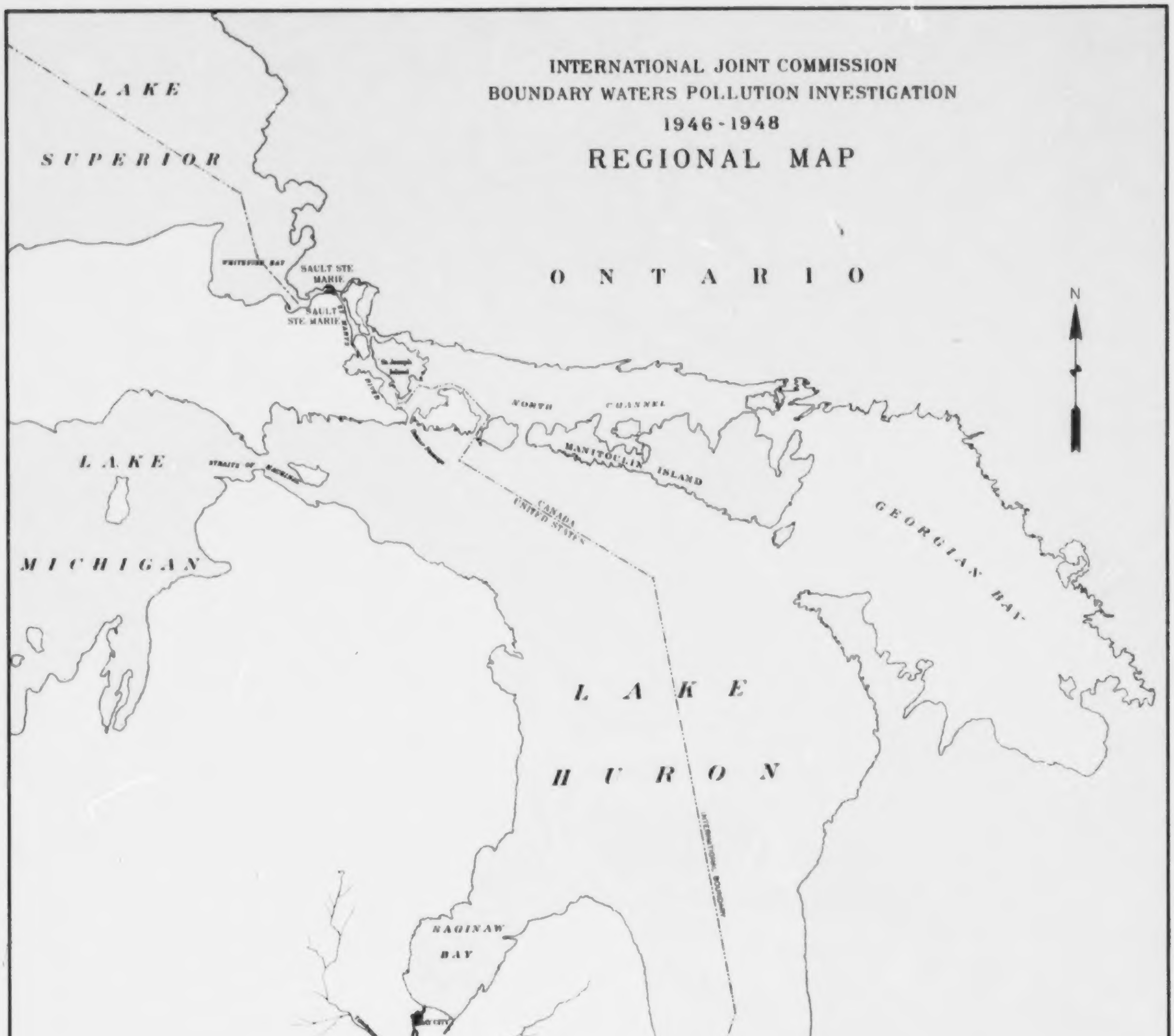
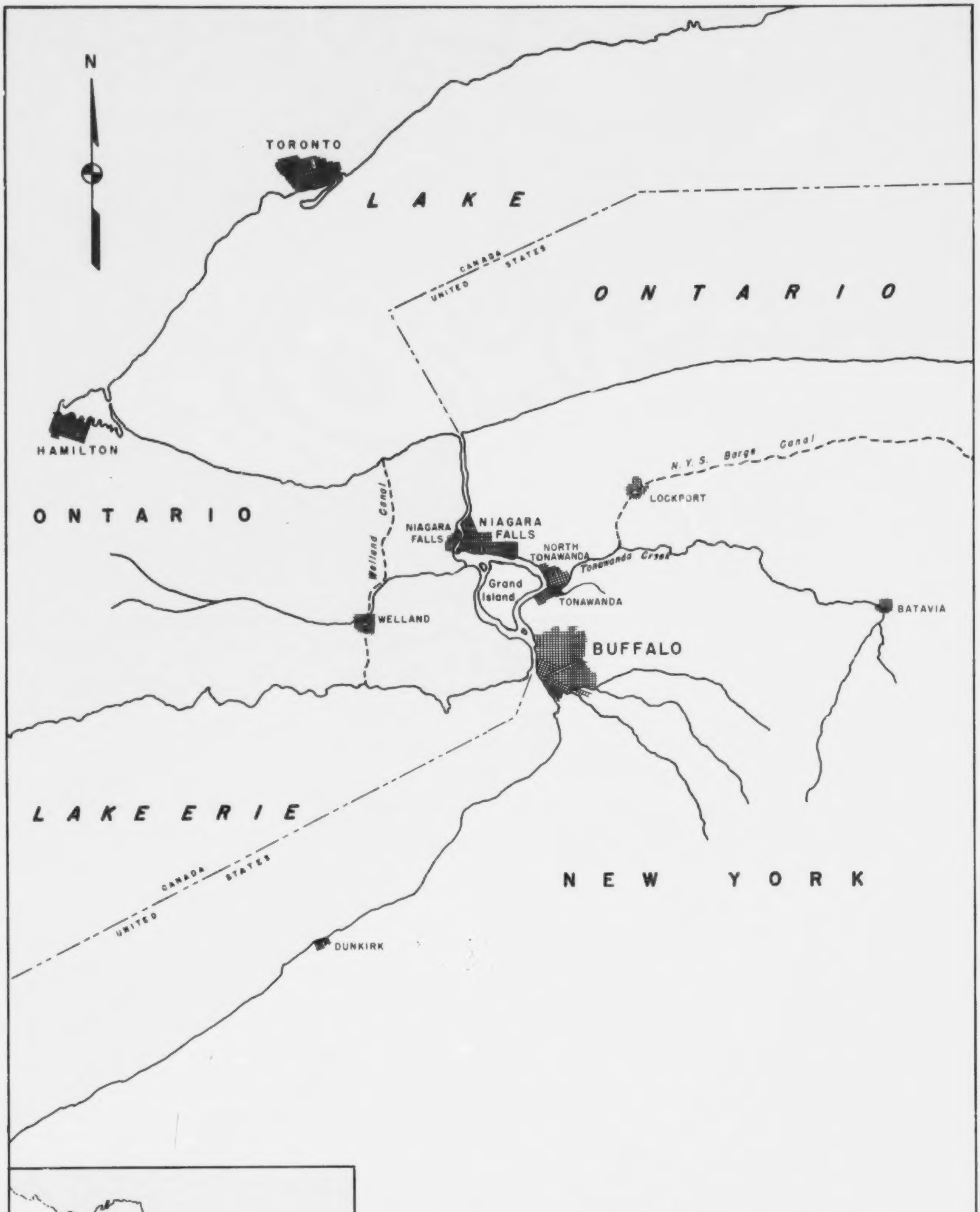


INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946-1948
REGIONAL MAP

LAKE SUPERIOR
WHITEFISH BAY
SAULT STE MARIE
SAULT STE. MARIE
ST. MARYS RIVER
St. Joseph Island
ONTARIO
N
NORTH CHANNEL
MANITOULIN ISLAND
LAKE MICHIGAN
STRAITS OF MACKINAC
CANADA
UNITED STATES
GEORGIAN BAY
LAKE HURON
INTERNATIONAL BOUNDARY
SAGINAW BAY
BAY CITY
SAGINAW
ONTARIO
PORT HURON
SARNIA
ST. CLAIR RIVER
MICHIGAN
LAKE ST CLAIR
DETROIT
WINDSOR
DETROIT RIVER
MICHIGAN
OHIO
TOLEDO
CANADA
UNITED STATES
LAKE ERIE
PENNSYLVANIA
OHIO
CLEVELAND
OHIO
STATUTE MILES

Army-U.S. Lake Survey Detroit-Litho. 1949-500
R-1951-6000


N
TORONTO
LAKE ONTARIO
CANADA
UNITED STATES
HAMILTON
ONTARIO
Welland Canal
NIAGARA FALLS
NIAGARA FALLS
N. Y. S. Barge Canal
LOCKPORT
NORTH TONAWANDA
Tonawanda Creek
Grand Island
TONAWANDA
WELLAND
BUFFALO
BATAVIA
LAKE ERIE
CANADA
UNITED STATES
NEW YORK
DUNKIRK
STATUTE MILES
10 0 10 20 30 40 50

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 – 1949

REGIONAL MAP

Army-U.S. Lake Survey, Detroit-Litho 1950-500
R-1351-6000

Report of
The International Joint Commission
United States and Canada
On The
Pollution Of Boundary Waters

The Secretary of State for the Government of the United States and the Secretary of State for External Affairs for the Government of Canada on April 1, 1946, made the following Reference to the International Joint Commission through identical letters addressed to the United States and Canadian sections of the Commission.

> "I have the honor to advise you that the Governments of the United States and Canada have been informed that the waters of the St. Clair River, Lake St. Clair and the Detroit River are being polluted by sewage and industrial wastes emptied into those waters. Having in mind the provisions of Article IV of the Boundary Waters Treaty signed January 11, 1909, that boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other side, the two Governments have agreed upon a joint Reference on the matter to the International Joint Commission, pursuant to the provisions of Article IX of said Treaty. The Commission is requested to inquire into and report to the two Governments upon the following questions:
>
> (1) Are the waters referred to in the preceding paragraph, or any of them, actually being polluted on either side of the boundary to the injury of health or property on the other side of the boundary?
>
> (2) If the foregoing question is answered in the affirmative, to what extent, by what causes, and in what localities is such pollution taking place?
>
> (3) If the Commission should find that pollution of the character just referred to is taking place, what measures for remedying the situation would, in its judgment, be most practicable from the economic, sanitary and other points of view?
>
> (4) If the Commission should find that the construction or maintenance of remedial or preventive works is necessary to render the waters sanitary and suitable for domestic and other uses, it should indicate the nature, location and extent of such works, and the probable cost thereof, and by whom and in what proportions such cost should be borne.
>
> For the purpose of assisting the Commission in making the investigation and recommendations provided for in this Reference, the two Governments will, upon request, make available to the Commission the services of engineers and other specially qualified personnel of their governmental agencies, and such information and technical data as may have been acquired by such agencies or as may be acquired by them during the course of the investigation.
>
> The Commission should submit its report and recommendations to the two Governments as soon as practicable."

EXTENSION OF THE REFERENCE TO INCLUDE THE ST. MARYS RIVER

The Government of Canada, on October 2, 1946, and the Government of the United States, on October 3, 1946, transmitted supplementary letters to the Commission, extending the scope of the foregoing Reference to include the waters of the St. Marys River from Lake Superior to Lake Huron.

APPOINTMENT OF BOARD OF TECHNICAL ADVISERS

Upon receipt of the Reference, the Commission, in May 1946, appointed a board of sanitary experts to act as technical advisers to the Commission. In addition to the personnel made available by the two Governments, the Board included representatives of the State of Michigan and the Province of Ontario. Members of the board were:

For the United States

J. K. Hoskins, Chief, Sanitary Engineering Division, and Assistant Surgeon General, U. S. Public Health Service, Washington, D. C. (1946-1947)

L. M. Fisher, Sanitary Engineer Director, U. S. Public Health Service, Washington, D. C. (1947-1949)

L. F. Warrick, Senior Sanitary Engineer, U. S. Public Health Service, Washington, D. C. (1949-1950)

M. LeBosquet, Jr., Sanitary Engineer Director, U. S. Public Health Service, Cincinnati, Ohio.

For Canada

G. H. Ferguson, Chief, Public Health Engineering Division, Department of National Health and Welfare, Ottawa, Ontario.

W. R. Edmonds, Senior Sanitary Engineer, Public Health Engineering Division, Department of National Health and Welfare, Ottawa, Ontario.

For Michigan

J. M. Hepler, Director, Division of Engineering, Michigan Department of Health, Lansing, Michigan.

L. F. Oeming, Sanitary Engineer, Michigan Stream Control Commission, Lansing, Michigan.

For Ontario

A. E. Berry, Director, Division of Sanitary Engineering, Ontario Department of Health, Toronto, Ontario.

A. V. DeLaporte, Chemical Engineer, in charge of Experimental Station, Ontario Department of Health, Toronto, Ontario.

The foregoing Board was requested by the Commission to advise also on the October extension of the Reference to cover the St. Marys River from Lake Superior to Lake Huron.

EXTENSION OF REFERENCE TO INCLUDE THE NIAGARA RIVER AREA

The scope of the Reference was again extended on April 2, 1948 to cover the waters of the Niagara River from Lake Erie to Lake Ontario. Inasmuch as this section involved different State representation, the Commission appointed a separate Board of Technical Advisers, as follows:

For the United States

L. M. Fisher, Sanitary Engineer Director, U. S. Public Health Service, Washington, D. C. (1948-1949)

L. F. Warrick, Senior Sanitary Engineer, U. S. Public Health Service, Washington, D. C. (1949-1950)

M. LeBosquet, Jr., Sanitary Engineer Director, U. S. Public Health Service, Cincinnati, Ohio.

For Canada

J. R. Menzies, Chief, Public Health Engineering Division, Department of National Health and Welfare, Ottawa, Ontario.

W. R. Edmonds, Senior Sanitary Engineer, Public Health Engineering Division, Department of National Health and Welfare, Ottawa, Ontario.

For New York

Earl Devendorf, Director, Bureau of Environmental Sanitation, New York State Department of Health, Albany, N. Y.

C. R. Cox, Chief, Water Supply Section, Bureau of Environmental Sanitation, New York State Department of Health, Albany, N. Y.

For Ontario

A. E. Berry, Director, Division of Sanitary Engineering, Ontario Department of Health, Toronto, Ontario.

A. V. DeLaporte, Chemical Engineer, in charge of Experimental Station, Ontario Department of Health, Toronto, Ontario.

DESCRIPTION OF AREA COVERED

This report of the International Joint Commission covers all three of the areas specified in the original Reference and its two extensions. The three areas, for which separate reports were made by the technical advisers, are as follows:

Lake Superior-Lake Huron Section

This section is the relatively small and sparsely settled region adjacent to the St. Marys River, the connecting water between Lake Superior and Lake Huron. The area of principal interest is the vicinity of the adjoining cities of Sault Ste. Marie, Michigan and Sault Ste. Marie, Ontario, with a combined population of 47,000 (estimated in 1948) and where there are several industrial developments, including a steel mill, a pulp and paper mill, a tar and chemical plant, a carbide manufacturing plant and a leather processing plant.

Lake Huron-Lake Erie Section

The waters connecting Lakes Huron and Erie include the St. Clair River, 40 miles in length, Lake St. Clair, a shallow basin of 430 square miles and the Detroit River, 31 miles in length. This is a heavily settled area with a population, estimated in 1948, of 3,487,000, of which 85 percent is urban, concentrated principally in the highly industrialized Detroit-Windsor area. These connecting waters, which have an average flow of 177,000 cubic feet per second at Detroit, constitute one of the world's greatest waterways. They carry a tonnage, principally ore, coal and grain, which exceeds that of any other waterway in the world. The region encompasses one of North America's most important industrial areas. The region is also highly developed for residential and recreational purposes and the use of the waters under reference for domestic supply, sanitation, industry, recreation, and fish and wildlife is vital to the people of the area.

Lake Erie-Lake Ontario Section

The area adjacent to the Niagara River which connects Lakes Erie and Ontario, has a population, estimated in 1949, of 1,125,000 of which 81 percent is urban, concentrated principally at Buffalo, Tonawanda, North Tonawanda, and Niagara Falls, New York, and at Niagara Falls in Ontario. The Niagara River, about 37 miles in length, falls 326 feet from Lake Erie to Lake Ontario. About half of this fall is concentrated at Niagara Falls, midway in the length of the river. The unusually uniform flow, averaging 202,000 cubic feet per second at the outlet of Lake Erie, and the concentrated drop make possible the development of low cost hydro-electric power which has attracted many industries including electro-chemical, ferro-alloy, abrasive, chlorine and caustic soda, carbide, steel, fertilizer and pulp and paper.

PROCEDURE OF THE INVESTIGATION

The necessary surveys and studies of the pollution problem were organized by the technical advisers and carried out through the cooperation of the appropriate Federal, State and Provincial agencies concerned. Details of the investigation are given in the reports of the technical advisers which are appended and form part of the Commission's report.

It is pertinent to record that the Commission has found this procedure eminently satisfactory. The boards of technical advisers were made up of senior experts who held positions of responsibility in either country on some activity related to the pollution problem. These experts were able, as a result of their familiarity with the problem, to plan the investigation soundly and, through their official administrative connections, were able to bring the full resources of appropriate governmental agencies in both countries to bear directly upon the problem. Circuitous, time-consuming procedures were thus avoided and the investigations were more comprehensive, more efficiently conducted, and more economical than would have been possible by other procedures. The Commission makes this observation for consideration in connection with possible future references and as an expression of appreciation of the excellent cooperation of all those who participated in these investigations, particularly the representatives of the Province of Ontario and the States of Michigan and New York.

As a preliminary to the investigations, the technical advisers had access to reports on the previous comprehensive pollution studies undertaken by the Commission in 1912, the conclusions of which were published in the final report of the Commission in 1918. Data on the physical characteristics, activities and population of the area were assembled and studied. Examinations were made of known and potential sources of pollution including the waste disposal practices of 61 municipalities, 101 industries and the vessels navigating the waters under reference. More than 100,000 laboratory determinations for bacteriological, limnological, physical and chemical characteristics were made from water samples. Hydrometric data, observations of travel of specific contaminants and results of float tests were analyzed to determine transboundary effects.

Numerous conferences were held by the technical advisers with representatives of municipalities and industries, culminating in a series of public hearings before the Commission to obtain information on waste treatment processes in use or proposed, estimates of cost and time required for institution of the necessary pollution control measures and the views of all concerned towards the specific objectives for pollution control which the Commission had adopted. These hearings took place as follows:

Detroit, Michigan	June 28, 29, 30, 1948
Detroit, Michigan	Sept. 8, 9, 10, 1948
Detroit, Michigan	Nov. 15, 16, 1948
Windsor, Ontario	Nov. 17, 18, 19, 20, 1948
Sault Ste. Marie, Ontario	Nov. 22, 1948
Detroit, Michigan	June 28, 29, 1949
Buffalo, New York	Nov. 15, 16, 1949
Niagara Falls, Ontario	Nov. 17, 1949
Buffalo, New York	Dec. 13, 14, 15, 1949

The results of the extensive field surveys and studies are presented in detail in the reports of the technical advisers which form a part of this report. The findings and recommendations which the Commission has arrived at, after consideration of the results of the investigations and of the Commission's public hearings, are outlined below.

NATURE AND EXTENT OF THE POLLUTION PROBLEM

The population of the 61 municipalities in the three regions covered by this report is 3,557,900. Approximately 96 percent is served by sewer systems and 86 percent has primary treatment of the wastes before discharge into the international waters under reference. Only a minor percentage is served by systems with secondary or biological treatment. Despite the partial treatment afforded the major portion of domestic sewage, the bacterial concentration in these waters is in places three to four times greater, on the average, than it was in 1912. The total discharge of municipal wastes into the boundary waters under reference is about 750 million U. S. gallons (625 million Imperial gallons) daily. About one-fifth of this amount is untreated and practically all of the remainder is only partially treated.

Industrial wastes, which were of little concern in 1912, are now a major problem. The daily discharge into these boundary waters now averages more than 2 billion U. S. gallons (approximately 1¾ billion Imperial gallons). While much of this is condenser and cooling water which has not been adversely affected by its use for industrial purposes, an appreciable volume of harmful pollutants is discharged daily. These include some 13,000 pounds of phenols, 8,000 pounds of cyanides, 25,000 pounds of ammonium compounds and large quantities of oils and suspended solids of all types.

In addition to the toxic effects of some of the pollutants as discussed later, the industrial waste discharge has a biochemical oxygen demand (B.O.D.) equivalent to the oxygen demand of the untreated sanitary wastes from a population of more than 4,000,000. Thus the industrial wastes produce a greater oxygen requirement on the receiving streams than the combined total of the domestic wastes of the area.

The wastes from vessel traffic through these international waters also constitute a pollution problem. The sewage from vessels at the height of the navigation season is the equivalent of the wastes contributed from a population of 1000 in the St. Marys River area and a population of 3900 in the St. Clair-Detroit River area. In addition, disposal of garbage, bilge water and water ballast creates problems in ports and congested areas. Such disposal is particularly objectionable near water intakes and bathing beaches.

A further pollution problem arises in these waters in connection with the dredging of channels for navigation. The dumping of contaminated dredged material in the Detroit River results in a concentration of pollution in a critical section of the river.

EFFECTS OF THE POLLUTION

The discharge of untreated and partially treated municipal wastes into these waters has created a serious health menace and has had adverse economic effects as well. The waterways being polluted are used as a source of domestic water supply for a population of 4 million persons. The extra treatment necessary to make the water safe for domestic use adds to the cost of water supplies. Furthermore, the bacterial concentration at water intakes varies widely and a constant threat exists that extremely high concentrations may occur so suddenly and change so quickly that treatment measures cannot be adjusted to meet them. The precautionary measures that can be taken at water supply intakes are incapable of insuring that such "slugs" of polluted water will not enter the water supplies and cause injury to the health of many water users. The only effective remedy lies in preventing the "slugs" from reaching the water intakes.

Bacterial concentrations at bathing beaches are also a health menace and cause economic losses when beaches must be closed during unsafe periods. Waterfront property values are also adversely affected by unsafe or undesirable conditions caused by pollution.

Industrial wastes contain numerous substances which are not susceptible to water treatment measures commonly used. There is danger to health if concentrations of some of these substances should enter water supplies. Objectionable tastes in domestic water have already been experienced in a number of localities. Fish and wildlife are destroyed by a number of industrial pollutants.

In general, the cumulative effect of uncontrolled waste disposal into these boundary waters seriously reduces the capacity of the waters to perform many beneficial and necessary functions vital to the health, recreation and economy of the people of the area.

TRANSBOUNDARY EFFECTS OF POLLUTION

Several methods were employed to determine whether pollution originating on one side of the boundary had adverse effects on the other. In the 1912 investigation, evidence was presented to show that there was a definite crossing of pollution from one side of the boundary to the other. In the investigations for this report, observations of currents by means of float tests and study of specific cases of reported travel of pollutants from source to an observed destination demonstrated conclusively that pollution from sources on each side of the boundary had adverse effects on the other. The interchange of waters across the boundary is such that any pollution on either side is a matter of concern to both countries.

OBJECTIVES FOR BOUNDARY WATERS QUALITY CONTROL

In order to permit a more accurate evaluation of the nature and extent of pollution, its effects and the remedial measures necessary, the Commission, in the course of the investigation, adopted the following statement of objectives for boundary waters quality control which was developed by the technical advisers:

> "The term "boundary waters" as herein used shall include the waters defined in the references to the International Joint Commission dated April 1, 1946, October 2 and 3, 1946, and April 2, 1948 and are as follows:
>
> > St. Clair River, Lake St. Clair, the Detroit River, St. Marys River from Lake Superior to Lake Huron, and Niagara River from Lake Erie to Lake Ontario.
>
> These objectives are for the boundary waters in general, and it is anticipated that in certain specific instances, influenced by local conditions, more stringent requirements may be found necessary.
>
> ### *General Objectives*
>
> All wastes, including sanitary sewage, storm water, and industrial effluents, shall be in such condition when discharged into any stream that they will not create conditions in the boundary waters which will adversely affect the use of those waters for the following purposes: source of domestic water supply or industrial water supply, navigation, fish and wildlife, bathing, recreation, agriculture and other riparian activities.
>
> In general, adverse conditions are caused by:
>
> (A) Excessive bacterial, physical or chemical contamination.
> (B) Unnatural deposits in the stream, interfering with navigation, fish and wildlife, bathing, recreation, or destruction of aesthetic values.
> (C) Toxic substances and materials imparting objectionable tastes and odors to waters used for domestic or industrial purposes.
> (D) Floating materials, including oils, grease, garbage, sewage solids, or other refuse.
>
> ### *Specific Objectives*
>
> In more specific terms, adequate controls of pollution will necessitate the following objectives for:
>
> (A) *Sanitary Sewage, Storm Water, and Wastes from Water Craft*
>
> Sufficient treatment for adequate removal or reduction of solids, bacteria and chemical constituents which may interfere unreasonably with the use of these waters for purposes aforementioned. Adequate protection for these waters, except in certain specific instances influenced by local conditions, should be provided if the coliform M.P.N. median value does not exceed 2,400 per 100 ml. at any point in the waters following initial dilution.
>
> (B) *Industrial Wastes*
>
> (1) CHEMICAL WASTES—PHENOLIC TYPE
>
> Industrial waste effluents from phenolic hydro-carbon and other chemical plants will cause objectionable tastes or odors in drinking or industrial water supplies and may taint the flesh of fish.

Adequate protection should be provided for these waters if the concentration of phenol or phenol equivalents does not exceed an average of 2 p.p.b. and a maximum of 5 p.p.b. at any point in these waters following initial dilution. This quality in the receiving waters will probably be attained if plant effluents are limited to 20 p.p.b. of phenol or phenol equivalents.

Some of the industries producing phenolic wastes are: coke, synthetic resin, oil refining, petroleum cracking, tar, road oil, creosoting, wood distillation, and dye manufacturing plants.

(2) CHEMICAL WASTES—OTHER THAN PHENOLIC

Adequate protection should be provided if:

(a) The pH of these waters following initial dilution is not less than 6.7 nor more than 8.5. This quality in the receiving waters will probably be attained if plant effluents are adjusted to a pH value within the range of 5.5 and 10.6.

(b) The iron content of these waters following initial dilution does not exceed 0.3 p.p.m. This quality in the receiving waters will probably be attained if plant effluents are limited to 17 p.p.m. of iron in terms of Fe.

(c) The odor-producing substances in the effluent are reduced to a point that following initial dilution with these waters the mixture does not have a threshold odor number in excess of 8 due to such added material.

(d) Unnatural color and turbidity of the wastes are reduced to a point that these waters will not be offensive in appearance or otherwise unattractive for the afore-mentioned purposes.

(e) Oils and floating solids are reduced to a point such that they will not create fire hazards, coat hulls of water craft, injure fish or wildlife or their habitat, or will adversely affect public or private recreational development or other legitimate shore line developments or uses. Protection should be provided for these waters if plant effluents or storm water discharges from premises do not contain oils, as determined by extraction, in excess of 15 p.p.m., or a sufficient amount to create more than a faint iridescence. Some of the industries producing chemical wastes other than phenolic are: oil wells and petroleum refineries, gasoline filling stations and bulk stations, styrene copolymer, synthetic pharmaceutical, synthetic fibre, iron and steel, alkali chemical, rubber fabricating, dye manufacturing, and acid manufacturing plants.

(3) HIGHLY TOXIC WASTES

Adequate protection should be provided for these waters if substances highly toxic to human, fish, aquatic, or wildlife are eliminated or reduced to safe limits.

Some of the industries producing highly toxic wastes are: metal plating and finishing plants discharging cyanides, chromium or other toxic wastes; chemical or pharmaceutical plants and coke ovens. Wastes containing toxic concentrations of free halogens are included in this category.

(4) DEOXYGENATING WASTES

Adequate protection of these waters should result if sufficient treatment is provided for the substantial removal of solids, bacteria, chemical constituents and other substances capable of reducing the dissolved oxygen content of these waters unreasonably. Some of the industries producing these wastes are: tanneries, glue and gelatin plants, alcohol, including breweries and distilleries, wool scouring, pulp and paper, food processing plants such as meat packing and dairy plants, corn products, beet sugar, fish processing and dehydration plants."

Note: The methods of determination of the chemical constituents referred to in the preceding Objectives are as given in "Analytical Methods for Boundary Waters Quality Control," as prepared by the Board of Technical Advisers. Bacterial determinations are to include the presumptive and confirmed tests for the coliform group of bacteria as given in "Standard Methods for the Examination of Water and Sewage," American Public Health Association, New York.

CONSULTATION WITH VARIOUS INTERESTS CONCERNED

Copies of the foregoing "Objectives" were made available to municipalities, industries, and agencies concerned with the pollution problem. Conferences were then held by the technical advisers with representatives of municipalities and industries about their pollution problems and public hearings were held by the Commission to ascertain the view of all interested parties as to:

(a) The suitability of the "Objectives" proposed by the Commission.
(b) The nature and extent of specific pollution problems.
(c) The remedial measures completed, under way, or planned to alleviate pollution.
(d) The problems involved in organizing and financing pollution abatement.

The results of these conferences and hearings are summarized in the attached reports of the technical advisers. Records of the public hearings are on file in the offices of the Commission. In general, these consultations and the records of the hearings indicate clearly that the "Objectives" are reasonable and desirable. In general, all concerned support the proposal to eliminate harmful pollution and, since the announcement of the Commission's "Objectives", considerable progress has been made towards this end, particularly by industries. Many municipalities have plans for treatment of wastes but realization of their plans depends upon overcoming organizational and financial difficulties.

CONCLUSIONS

The conclusions of the Commission are summarized below under each of the questions contained in the Reference from the two Governments.

Question (1) *"Are the waters referred to in the preceding paragraph (of the reference), or any of them, actually being polluted on either side of the boundary to the injury of health or property on the other side of the boundary?"*

The Commission finds that the waters under reference are being polluted on either side of the boundary to the injury of health and property on the other side of the boundary.

Question (2) *"If the foregoing question is answered in the affirmative, to what extent, by what causes, and in what localities is such pollution taking place?"*

The Commission finds that the pollution of the boundary waters under reference is taking place to an extent which is injurious to health and property, principally by reason of domestic sewage and industrial wastes discharged along the shores of boundary waters, on tributaries of the boundary waters, and, to a lesser extent, by sewage and other wastes discharged from vessels engaged in passenger and freight traffic on these waters. There is progressive overall degradation of the waters in the lower St. Marys River, the St. Clair River, the Detroit River and the upper Niagara River. Dredging operations contribute to the diffusion of pollution.

The most serious pollution, principally from untreated or inadequately treated sewage and industrial wastes, occurs throughout the Lake Huron-Lake Erie section; but is heaviest in the upper St. Clair River, along the west shore of Lake St. Clair, in the lower Detroit River and the west end of Lake Erie. Serious pollution from both sewage and industrial wastes is also taking place in the upper St. Marys River, principally at and near Sault Ste. Marie and along the United States side of the east end of Lake Erie and on the upper Niagara River.

Question (3) *"If the Commission should find that pollution of the character referred to is taking place, what measures for remedying the situation would, in its judgment, be most practicable from the economic, sanitary and other points of view?"*

The Commission is of the opinion that all wastes discharged into the waters under reference should be treated to comply with the "Objectives for Boundary Waters Quality Control" set forth in this report. Specific remedial measures required to meet these objectives are discussed in the accompanying reports of the technical advisers and are summarized in the Commission's finding on the next question.

Question (4) "If the Commission should find that the construction or maintenance of remedial or preventive works is necessary to render the waters sanitary and suitable for domestic and other uses, it should indicate the nature, location and extent of such works, and the probable cost thereof, and by whom and in what proportions such cost should be borne."

Treatment of municipal wastes by sedimentation and disinfection of the effluent is urgently needed and should be undertaken as the initial step by all municipalities where all wastes are not already afforded such primary treatment. This should be followed by a more efficient or secondary treatment where necessary in order to meet the requirements of the "Objectives." Treatment of overflows from sewers in which both storm water and sanitary wastes are combined should be provided during storm periods where needed. The estimated cost of necessary primary treatment measures, in the three areas under reference, is $43,500,000 in the United States and $21,000,000 in Canada. The estimated cost of the secondary treatment needed is $33,000,000 in the United States and $4,000,000 in Canada.

Treatment of industrial wastes is already being provided to a considerable degree but further treatment in a number of ways to meet the wide range of conditions at the various industries is needed in many cases and should be provided as set forth in the accompanying reports. The estimated cost of treatment of industrial wastes in the three areas under reference is $22,650,000 in the United States and $3,450,000 in Canada.

Vessels plying these waters should be equipped with holding tanks for retention and disinfection of sanitary wastes. Measures to control the escape of oil and dumping of all refuse from vessels should be instituted by the appropriate authorities.

Dredged material should be disposed of in such a manner and at such locations as will not result in harmful transfer of polluting substances in the waters under reference.

The Commission considers that the costs of the necessary remedial measures should be borne by the municipalities, industries, vessel owners and others responsible for the pollution.

With respect to pollution originating from sources other than vessels, the Commission finds that there is adequate legal and administrative authority in each country to enforce proper waste disposal objectives. With respect to pollution from vessels, there is existing legislation applicable only to certain aspects of the problem and consideration should therefore be given in each country to the additional legislation necessary for adequate control of pollution from vessels.

One of the principal requirements for enforcement of quality control objectives in these boundary waters is a procedure whereby an official determination that improper waste disposal practices exist can be brought to the attention of the appropriate enforcement authority.

RECOMMENDATIONS

(1) The Commission recommends that the "Objectives for Boundary Waters Quality Control" as set forth in this report be adopted by the two Governments as the criteria to be met in maintaining boundary waters in satisfactory condition, as contemplated in that portion of Article IV of the Boundary Waters Treaty of 1909 wherein it is stated: "It is further agreed that the waters herein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other."

(2) The Commission recommends that the remedial measures already known to be necessary as described in the accompanying reports of the technical advisers be put into effect and that additional measures be undertaken as may prove to be necessary in the future to meet the recommended "Objectives".

(3) As a procedure to insure accomplishment of the foregoing, the Commission recommends that it be specifically authorized by the two Governments to establish and maintain continuing supervision over

boundary waters pollution through boards of control appointed by the Commission. In carrying out this supervisory function, the Commission shall notify those responsible for any pollution found objectionable in the light of the objectives recommended above and, in the event that assurance is not received that such pollution will be corrected in a reasonable time, shall make recommendations to the appropriate authority having jurisdiction as to the further action deemed advisable.

Signed at Ottawa, Canada, this 11th day of October, 1950.

A. G. L. McNaughton
A. O. Stanley
George Spence
Roger B. McWhorter
J. Lucien Dansereau
Eugene W. Weber

REPORTS

OF THE

BOARDS OF TECHNICAL ADVISERS

TO THE

INTERNATIONAL JOINT COMMISSION

ON THE

POLLUTION OF INTERNATIONAL BOUNDARY WATERS

1946 - 1949 INVESTIGATIONS

LAKE HURON — LAKE ERIE SECTION

LAKE SUPERIOR — LAKE HURON SECTION

LAKE ERIE — LAKE ONTARIO SECTION

23

LETTER OF SUBMITTAL

(Lake Huron-Lake Erie and Lake Superior-Lake Huron Sections)

To the International Joint Commission

United States and Canada

The Board of Technical Advisers submits herewith its report on pollution in that section of the International Boundary Waters covered by the references to the Commission, dated April 1, and October 2, 1946.

Respectfully submitted,

Board of Technical Advisers

UNITED STATES

L. M. Fisher, *Chairman*

M. LeBosquet, Jr.

John N. Hepler

L. F. Oeming

CANADA

E. H. Ferguson, *Chairman*

W. R. Edmonds

A. E. Berry

A. V. DeLaporte

August 24, 1949

ACKNOWLEDGMENTS

(Lake Huron-Lake Erie and Lake Superior-Lake Huron Sections)

Invaluable assistance has been rendered, during this investigation, by the various municipalities and industries as well as several State, Provincial, and Federal agencies on both sides of the boundary. Special acknowledgment is made to the following:

On the United States side to:

City of Detroit
Huron-Clinton Metropolitan Authority
Michigan Stream Control Commission
Michigan Department of Health
U. S. Air Forces
U. S. Coast Guard, Ninth District
U. S. Corps of Engineers, Detroit District
U. S. Geological Survey
U. S. Lake Survey
U. S. Navy, Grosse Ile (Michigan) Air Station
U. S. Public Health Service, Environmental Health Center

and on the Canadian side to:

City of Sarnia
City of Windsor
Chamber of Commerce of Windsor
Ontario Department of Health
Department of Mines and Resources of Canada
Department of National Health and Welfare
Department of Transport of Canada
Royal Canadian Air Force
Royal Canadian Mounted Police—Marine Division, Windsor District

PERSONNEL

(Lake Huron-Lake Erie and Lake Superior-Lake Huron Sections)

The personnel assigned to conduct the field work in the 1946-1948 investigation were made available by the U. S. Public Health Service, the Department of National Health and Welfare of Canada, and the Ontario Department of Health, as follows:

United States field staff:

- Hayse H. Black, Sanitary Engineer, Officer in Charge—July 1946-November 1947
- Ralph C. Palange, Sanitary Engineer, Officer in Charge—December 1947-August 1949
- Ralph J. Johnson, Sanitary Engineer
- Paul Agnano, Sanitary Engineer (Reserve)
- Gordon G. Robeck, Assistant Sanitary Engineer (Reserve)
- Francis M. Middleton, Senior Assistant Scientist (chemist)
- Gerhardt E. Terhoeven, Senior Assistant Sanitarian (Reserve) (chemist)
- Arthur M. Hanson, Chemist
- Robert C. Kroner, Chemist
- William W. Walker, Chemist
- Milton Reier, Chemist
- Noah N. Norman, Senior Assistant Sanitarian (Reserve) (bacteriologist)
- Leo M. Reading, Bacteriologist
- Paul F. Jones, Engineering Aide

Canadian field staff:

- A. Valentine DeLaporte, Chemical Engineer in Charge (Ontario Department of Health)
- Department of National Health and Welfare:
  - William R. Edmonds, Senior Sanitary Engineer
  - Robert K. Pequegnat, Senior Sanitary Engineer
  - Wallace S. Tait, Sanitary Engineer
  - Frank C. Totino, Sanitary Engineer
  - John P. Ward, Sanitary Engineer
  - John E. Wilson, Sanitary Engineer
- Ontario Department of Health:
  - James G. Duncan, Senior Chemical Engineer
  - Ian G. Simmonds, Chemical Engineer
  - Anthony F. Fassel, Sanitary Engineer
  - Kenneth H. Sharpe, Sanitary Engineer

Acknowledgment is made to V. G. MacKenzie, H. W. Streeter, C. T. Butterfield, C. C. Ruchhoft, and M. B. Ettinger, of the U. S. Public Health Service, for their advice and assistance during the conduct of this investigation. In addition, Messrs. Ruchhoft, Ettinger, and Duncan served on a special committee in the preparation of "Analytical Methods for Boundary Waters Quality Control."

Lake Huron – Lake Erie Section

1946-1948

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The following appendices were submitted with the original report and are on file in the offices of the International Joint Commission but are not reproduced herein:

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Appendix D — Detroit Sewage Treatment Plant Studies
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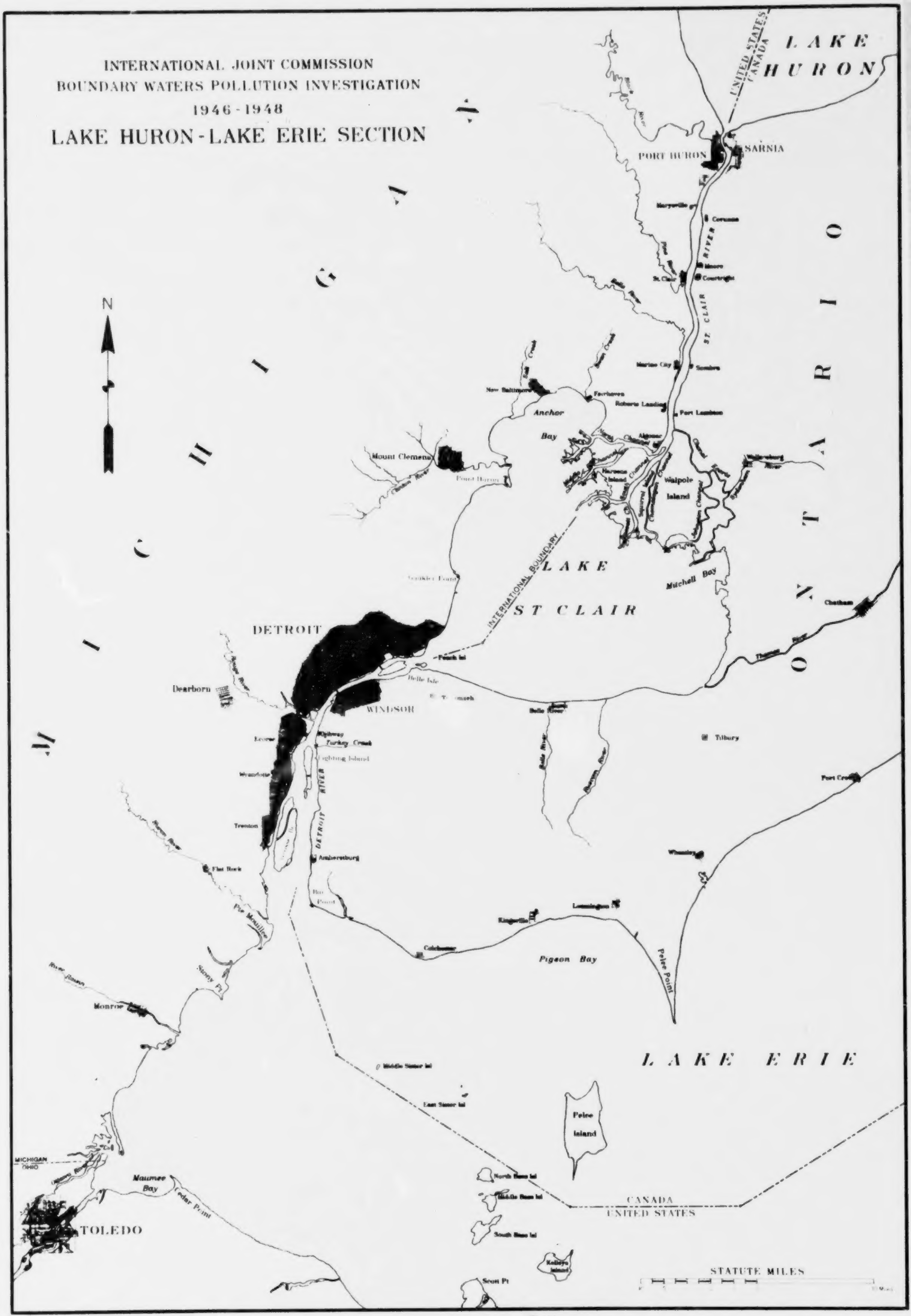
INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946-1948
LAKE HURON-LAKE ERIE SECTION
N
LAKE HURON
UNITED STATES
CANADA
PORT HURON
SARNIA
Marysville
Corunna
ST CLAIR RIVER
St. Clair
Mooretown
Courtright
Belle River
Marine City
Sombra
New Baltimore
Fairhaven
Roberts Landing
Port Lambton
Anchor Bay
Algonac
Harsens Island
Walpole Island
Mount Clemens
Clinton River
Wallaceburg
Sydenham River
MICHIGAN
ONTARIO
INTERNATIONAL BOUNDARY
LAKE ST CLAIR
Mitchell Bay
Chatham
Thames River
DETROIT
Peach Isl
Belle Isle
Tecumseh
Belle River
Dearborn
Rouge River
WINDSOR
Ecorse
Ojibway
Turkey Creek
Fighting Island
Wyandotte
Trenton
DETROIT RIVER
Amherstburg
Tilbury
Port Crewe
Wheatley
Flat Rock
Huron River
Bar Point
Leamington
Kingsville
Colchester
Pigeon Bay
Pelee Point
Pte Mouillee
Stony Pt
River Raisin
Monroe
LAKE ERIE
Middle Sister Isl
East Sister Isl
Pelee Island
MICHIGAN
OHIO
Maumee Bay
Cedar Point
TOLEDO
North Bass Isl
Middle Bass Isl
South Bass Isl
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Scott Pt
CANADA
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Chapter I

FINDINGS AND RECOMMENDATIONS

The investigation of pollution in the boundary waters of the Lake Huron-Lake Erie section has extended over the period of July, 1946, to December, 1948. In that time a comprehensive examination has been made of all phases of pollution, and relevant information has been obtained from many sources. These data have been studied and conclusions reached on the questions contained in the terms of reference to the International Joint Commission by the governments of the two countries.

This study has involved unique and complex problems. The previous investigation in 1913 was a pioneering effort in the evaluation of bacteriological pollution. In the intervening period these waters have assumed an unparalleled role in serving numerous uses on a boundary between two countries where healthful living, commerce, and recreation have attained a high level of development. These activities have focused attention on two necessities: first, the imperative need for clean waters, and secondly, the serious problem of attaining this objective. Concentration of population in urban communities, combined with tremendous advances in new industrial processes with complex waste products, has given rise to involved and complicated requirements both for the investigation and solution of this situation. The cost is high for correction, but it is higher for continuance of the defilement of these waters.

The investigation has enabled the Board of Technical Advisers to reach certain conclusions on the findings and to offer recommendations to the Commission for remedial measures. The findings of the Board are discussed in Chapter X and are summarized herewith.

Findings

1. These waters are seriously polluted in many places on both sides of the boundary. The most serious pollution exists in the St. Clair River below Port Huron and Sarnia, in Lake St. Clair along the west shore, in the Detroit River below Belle Isle, and in Lake Erie at the west end. There is progressive over-all degradation of the water between Lake Huron and Lake Erie.
2. There is a transfer of pollution from each side of the boundary to the other. This has been demonstrated by float studies, by analytical results, and by accidental discharges of specific substances.
3. There has been injury to health and property on both sides of the boundary. This has been manifested in the following ways:
   - a. Health—A potential menace is present where waters polluted to the extent of these are used for domestic purposes. They are in such condition that they cannot be safely used as a potable supply without complete and continuously effective treatment. Much of the threat to health arises from such factors as bacterial overloading beyond the safe limits of water purification processes; variations in pollution with accompanying erratic chlorine demand; interference of certain types of pollution with disinfectants which destroy their germicidal properties; and the probability of certain infections being carried through a water treatment process, especially if there is any interruption or breakdown in a part of that process. This condition occurred in Detroit in 1926 when 45,000 cases of dysentery were reported among the water consumers.

     These waters are so polluted in many areas as to render them unsafe for bathing purposes. Both warning and prohibitory actions in this respect have been taken by appropriate authorities. Case histories of some typhoid fever patients in Detroit have pointed strongly to infections contracted at a Lake St. Clair beach. This damage is not only reflected in cases of typhoid fever and other reportable diseases, but it may include enteric, ear, and upper respiratory infections.

     The sewage pollution present in these boundary waters must be considered as an actual and potential health hazard, whether it be through public water supplies, bathing beaches, or other vectors. If the 1913 to 1948 trend in water pollution is permitted to continue the time will come when conditions will reach a point where it will be impossible to use these waters safely for domestic purposes.
   - b. Property—Injury to property has been illustrated in the cost of extending water

intakes and of water treatment, both for municipalities and industries; in economic loss to owners of bathing beaches and other waterfront property; in damage to water craft; and in destruction of fish and wildlife.

   c. Industry—There is evidence that these waters are polluted to such a degree as to affect their use in certain industries. An economic loss to the community, and to industry as well will occur when a plant is unable to locate in an area because of inability to secure a satisfactory water supply.

4. Substantial progress has been made in control or elimination of pollution during the period of this investigation. Both municipalities and industries have contributed to this activity. Municipal progress has been confined largely to the planning stages, whereas industry has advanced many of its programs to the construction stage. As a result of improved control of industrial waste discharges, taste difficulties in municipal water supplies were much less pronounced at the conclusion of this study than prior to 1946.
5. Public hearings held by the Commission revealed a common acceptance on the part of municipal officials and industrial management of the presence of serious pollution in these waters and the need for correction. The hearings also substantiated the findings of the Advisory Board that there was injury to health and property and interference with the various water uses on both sides of the boundary. Financing of the necessary remedial works was asserted by municipal officials to be the principal obstacle to correction.
6. Frequent releases of pollution in the form of slugs or spills create intensified injury to the users of these waters and cause acute difficulties in water purification plants.
7. The condition of these waters requires that remedial measures be undertaken as early as possible.

Recommendations

The Advisory Board respectfully offers the following recommendations to the Commission:

1. Remedial measures for the abatement and control of pollution in the Lake Huron-Lake Erie section of the boundary waters be undertaken at the earliest possible date. These measures should be sufficient to restore and protect the uses of these waters to which the people of both countries are rightfully entitled. Major consideration should be given to uses for domestic and industrial water supplies, recreation, fish and wildlife, sanitary purposes, and navigation.
2. The "Objectives for Boundary Waters Quality Control," prescribed in this report, be recognized in the development of remedial and pollution-preventive measures by municipalities and industry. These objectives should apply to both existing and new sources of wastes.
3. Treatment of municipal wastes by sedimentation and disinfection of the effluent be undertaken by all communities as the initial step; that a program of more efficient or secondary treatment be inaugurated at as early a date as possible; and that a median coliform M. P. N. value not exceeding 2400 per 100 ml. as set forth in the "Objectives for Boundary Waters Quality Control" at any point in these waters, following initial dilution of waste discharges, be considered as the objective for bacterial control to attain reasonable stream sanitation. The more efficient or secondary treatment recommended will be most urgent in those zones of concentrated discharge near large centers of population or where much industrial waste is involved. It is recognized that local conditions, on either side of the boundary, may give additional emphasis to the need for this higher degree of treatment. The estimated cost for installation of intercepting sewers and primary treatment works for municipalities in this section is $51,000,000, of which $35,000,000 is for United States and $16,000,000 for Canadian communities. For the additional cost of secondary treatment of municipal wastes the estimate is $37,000,000, of which $33,000,000 is on the United States side and $4,000,000 on the Canadian side. These works must be financed through public funds.
4. Overflows from combined sewers during storm periods be treated by sedimentation and disinfection or by other methods where necessary to protect the purposes for which these waters are or may be utliized.
5. Industrial wastes be treated to comply, as soon as possible, with the "Objectives for Boundary Waters Quality Control." The estimated cost for industrial waste treatment works is $16,000,000, of which $13,000,000 is for United States and $3,000,000 for Canadian industries. The correction and prevention of pollution resulting from the disposal of industrial wastes is the responsibility of industry.

6. Slugs and spills of objectionable wastes from industrial plants be avoided. Retention tanks or lagoons for equalizing rates of discharge may be utilized when approved by enforcing authorities where slugs and spills cannot otherwise be controlled.
7. Sewage from vessels equipped with flush toilets and from craft used for living purposes be controlled by the installation of holding tanks, and that the tanks be emptied either by transfer of the contents to shore treatment facilities or disinfected and dumped overboard in nonrestricted areas. No garbage or other refuse be discharged overboard into these waters.
8. Materials from dredging operations be dumped only at locations where they will not interfere with legitimate water uses.
9. Consideration be given to joint community action on metropolitan or regional bases in the effective solution of mutual water and sewerage problems in this section.
10. Definite plans for financing remedial municipal works be formulated. In this, there should be co-operation between the Commission and Federal, State, Provincial, and municipal governments.
11. Continuing contact with pollution control progress be maintained through a technical committee or board, having representation from both countries.
12. The Commission take such measures as may be legally available to it to have the pollution abatement and prevention program herein outlined initiated, promoted, and effectively prosecuted.

Chapter II

INITIATION OF THE INVESTIGATION

The Pollution Problem

The waters between the United States and Canada comprise the largest body of fresh water in the world. They are vitally important to health, recreation and the national economy of both countries. Large populations and great industries have developed along the shores of these watercourses, attracted by the available facilities so essential for domestic and industrial water supplies, recreation, drainage outlets, and for transportation and power. The welfare of these developments, and indirectly, of larger areas of both countries, is influenced in no small measure by maintenance of these waters free from objectionable pollution.

Pollution control is an ever changing problem, particularly in those watercourses subject to a variety of riparian activities. At one time the major source of contamination was human sewage, and the degree of bacterial pollution was the primary concern. This continues to be an important health problem, but industrial developments in both countries have added new factors. Their wastes produce effects additional to and different from those created by the concentration of sewage bacteria. Any or all of these industrial wastes may have a deleterious effect on the aesthetic qualities of the waters as well as on their physical and chemical properties. Their health significance is secondary to sewage but they may seriously impair the use of water for domestic, recreational, industrial and other purposes. The development of new products, the expansion of industrial activity, and modifications of industrial processes all cause variations in wastes which intensify the problems of water pollution control. This is further aggravated by the demand for the widest and fullest use of these waters by populations adjacent to the boundary.

The Previous Investigation

The pollution of boundary waters between the United States and Canada has been of concern to both countries for more than 40 years. Interest has been manifest in the extent, nature, and dispersion of pollution from each side of the boundary to the other. An answer to this situation was first sought when a comprehensive survey of these waters was undertaken in 1913 by the International Joint Commission. The "Progress Report of the International Joint Commission", dated January 16, 1914, showed clearly the extent of bacterial pollution at that time. The "Report of the Consulting Sanitary Engineer upon Remedial Measures", dated March 8, 1916, recommended procedures to be adopted for abating this pollution.

In the interval between 1913 and 1946, apart from the construction of some sewage disposal plants in the Detroit River area, much remained to be done in putting into effect the recommendations contained in the "Final Report of the International Joint Commission on the Pollution of Boundary Waters Reference", 1918. In this period many important changes took place in the area contiguous to this section of the boundary. The population increased rapidly, and a major industrial expansion occurred, particularly during the period of the second world war. These factors precipitated an interest in a further survey of pollution in the boundary waters.

Authorization of Survey

For undertaking this investigation the governments of the United States and Canada respectively requested the International Joint Commission to examine conditions in relation to treaty obligations. The first project comprised the Lake Huron-Lake Erie section, from Lake Huron above Port Huron and Sarnia to Lake Erie and the immediate waters at the entrance to Lake Erie.

The terms of reference of the two governments to the Commission, dated April 1, 1946, are as follows:

"I have the honour to inform you that the Governments of the United States and Canada have been informed that the waters of the St. Clair River, Lake St. Clair, and the Detroit River are being polluted by sewage and industrial wastes emptied into those waters. Having in mind the provisions of Article IV of the Boundary Waters Treaty signed January 11, 1909, that boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other side, the two Governments have agreed upon a joint Reference of the matter to the International Joint Commission, pursuant to the provisions of Article IX of said Treaty. The Commission is requested to inquire into and to report to the two Governments upon the following questions:

"(1) Are the waters referred to in the preceding paragraph, or any of them, actually being polluted on either side of the boundary to the injury of health or property on the other side of the boundary?

"(2) If the foregoing question is answered in the affirmative, to what extent, by what causes, and in what localities is such pollution taking place?

"(3) If the Commission should find that pollution of the character just referred to is taking place, what measures for remedying the situation would, in its judgment, be most practicable from the economic, sanitary and other points of view?

"(4) If the Commission should find that the construction or maintenance of remedial or preventive works is necessary to render the waters sanitary and suitable for domestic and other uses, it should indicate the nature, location and extent of such works, and the probable cost thereof, and by whom and in what proportions such cost should be borne.

"For the purpose of assisting the Commission in making the investigation and recommendations provided for in this Reference, the two Governments will, upon request, make available to the Commission the services of engineers and other specially qualified personnel of their governmental agencies, and such information and technical data as may have been acquired by such agencies, or as may be acquired by them during the course of the investigation.

"The Commission should submit its report and recommendations to the two Governments as soon as practicable."

Board of Technical Advisers

In accordance with the terms of reference the International Joint Commission appointed a Board of Sanitary Experts, to act as technical advisers to the Commission. The action of the Commission is set forth in the minutes of its executive meeting in Montreal, Canada, on May 15, 1946 as follows:

"That the Board of Sanitary Experts in the Pollution Investigation shall consist of eight members, two from the Federal services of the United States, two from the Federal services of Canada, two from the State services of Michigan, and two from the Provincial services of Ontario.

"That the members of the Board shall be:

For the United States

J. K. Hoskins, Chief, Sanitary Engineering Division, and Assistant Surgeon General, U. S. Public Health Service, Washington, D. C. (Later succeeded by L. M. Fisher, Sanitary Engineer Director, U. S. Public Health Service, Washington, D. C.)

M. LeBosquet, Jr., Senior Sanitary Engineer, U. S. Public Health Service, Cincinnati, Ohio.

For Canada

G. H. Ferguson, Chief, Public Health Engineering Division, Department of National Health and Welfare, Ottawa, Ontario.

W. R. Edmonds, Senior Sanitary Engineer, Public Health Engineering Division, Department of National Health and Welfare, Ottawa, Ontario.

For Michigan

J. M. Hepler, Director, Division of Engineering, Michigan Department of Health, Lansing, Michigan.

L. F. Oeming, Sanitary Engineer, Michigan Stream Control Commission, Lansing, Michigan.

For Ontario

A. E. Berry, Director, Division of Sanitary Engineering, Ontario Department of Health, Toronto, Ontario.

A. V. DeLaporte, Chemical Engineer, in charge of Experimental Station, Ontario Department of Health, Toronto, Ontario.

"That the Joint Chairmen of the Board of Sanitary Experts shall be J. K. Hoskins (later L. M. Fisher), whose duty it will be to preside over meetings of the Board in the United States, and G. H. Ferguson, who will preside over meetings in Canada. The two Chairmen will jointly act as liaison officers between the Board and the Commission.

"That the Board shall have authority to enlist the cooperation of technical officers of other Federal, Provincial or State Departments or agencies in the United States and Canada; to employ such technical and clerical assistance, to acquire such equipment, and to make such expenditures for travel, as may be found necessary."

Organization for Lake Huron - Lake Erie Investigation

Field work on the survey of the Lake Huron-Lake Erie section of the boundary waters was initiated in August, 1946. The personnel for this work was supplied by the U. S. Public Health Service, the Department of National Health and Welfare of Canada, the Michigan Stream Control Commission and the Ontario Department of Health. The field work on the United States side of the boundary was under the direction of H. H. Black, later succeeded by R. C. Palange, both Sanitary Engineers of the U. S. Public Health Service, and on the Canadian side under A. V. DeLaporte.

General Procedure

The Board of Technical Advisers organized the field work, distributing it between the United States and the Canadian field staffs. Each undertook to examine a part of the section. Later the same areas were examined by the other staff. Field laboratories were established at Detroit, Sarnia, and Windsor. The laboratories of the Ontario Department of Health at Toronto, Ontario, the Michigan Stream Control Commission at Wyandotte, Michigan, and the U. S. Public Health Service at Cincinnati, Ohio, were utilized for certain examinations in connection with industrial waste surveys. Field studies included sampling and analysis of the boundary waters and tributaries, float tests for determining the direction of currents, visual examinations of the waters, and investigations of industries and other sources of pollution.

Selection and Designation of Sampling Points

The selection of sampling points for this investigation was influenced by such factors as the location of known pollution sources, the characteristics of the stream flows, and the location of points used during the 1913 survey. The known pollution sources included municipal and industrial sewer outlets found along the shores of these waters and tributaries. Stream flow characteristics were considered significant in that they influence the dispersion of pollution throughout these boundary waters. Comparison of results with those of the 1913 survey was desired, and many of the sampling points used in the 1946-1948 investigation were the same.

For the purpose of identifying the location of sampling ranges, sewer outlets, and other important points on the rivers and their tributaries, a mileage index system was used for the present investigation. This system involves the use of one or more letters to identify the stream or streams, followed by a number which represents the distance in river miles from the mouth or other point of reference. The reference points correspond to the zero mileage points established by the U. S. Corps of Engineers.

The zero mileage point for the St. Clair River was taken in the South Channel, between Light No. 6 and Buoy No. 9, and for the Detroit River, at the Detroit River Light opposite Pointe Mouillee. (See figure 1). On the tributaries, the letter or letters designating the main stream are retained and another letter or letters added to designate the tributary. The mileage index figure used for the tributary represents the distance from the zero reference point of the main stream to the mouth of the tributary plus the mileage from the mouth of the tributary to the point or range concerned.

The letters used in designating the various streams, with the distances from the zero reference points to the tributary outlets, are given in table 1.

TABLE 1—RIVER AND LAKE DESIGNATIONS WITH MILEAGES FROM ZERO REFERENCE POINTS

Watercourse	Designation	Mileage
St. Clair River	SR	
Black River	SR Bk	36.5
Talford Creek	SR Ta	31.1
Baby Creek	SR Ba	26.3
Pine River	SR Pn	25.1
Belle River (U. S.)	SR Be	17.0
Lake St. Clair		
Sydenham River	Sy	
Chenal Ecarte	CE	
Thames River	Th	
Belle River (Canada)	Be	
Milk River	MR	
Clinton River	Cl	
North Branch	Cl N	11.2
Middle Branch	Cl M	11.2
Red Run	Cl RR	17.1
Beaver Creek	Cl RR Bv	22.0
Bear Creek	Cl RR Br	22.2
Detroit River	Dt	
Fox Creek	Dt Fx	30.8
Conner Creek	Dt Cn	29.5
Rouge River	Dt Rg	19.3
Ecorse River	Dt ER	16.2
Huron River	Dt Hn	1.6
Lake Erie		
Raisin River	Ra	

The river mileage index system was not adaptable for the lakes. For these, a grid system was established using Roman numerals and letters for the terminal points on each range. Sampling points were identified by the range designation and a number showing the distance in miles along the range from a fixed reference point. For tributaries discharging into the lakes, mileage index numbers indicate the distance from the mouth of the tributary at the lake to the point designated. Points on branches of tributaries were referred to the zero point of the main tributary.

Laboratory Determinations on River and Lake Samples

In the early stages of this investigation all recognized tests for measuring domestic and industrial pollution were made on a routine basis. Routine determinations included coliforms, chlorides, phenols, ammonia, chlorine demand, dissolved oxygen, biochemical oxygen demand, hydrogen ion concentration (pH), turbidity, and alkalinity. Tests for oils, cyanides, solids, tastes, and odors were made periodically. After it was found that certain of the routine tests would be of limited value in disclosing the nature or extent of the pollution, they were discontinued. This resulted, for example, in the elimination of the hydrogen ion concentration, alkalinity, and chloride tests at certain locations.

In general, analytical procedures followed were those contained in "Standard Methods for Water Analysis", 8th and 9th Editions. Specific techniques were developed where an accepted method was not available, where the standard test for a specific compound was not sensitive enough for the high dilutions encountered, or where other substances caused interference. Such special procedures included those for oil, phenols, cyanides, and tastes.

Possible variations in techniques between the laboratories of the two field staffs were recognized and guarded against in many ways. Specific batches of laboratory media were set aside for this investigation and all tests conducted in either laboratory were made with the same media. Sampling assignments were interchanged from time to time in order that any variations in techniques would tend to be minimized. Checks on analytical procedures were made by dividing samples between laboratories.

The number of samples collected and of analyses made during this investigation are presented in table 2.

TABLE 2—SAMPLES COLLECTED AND ANALYSES MADE

Area or Source	Bacteriological Examinations	Chemical Examinations	
		Samples	Determinations
Lake Huron........	94	272	544
St. Clair River.....	1,688	3,082	9,431
Lake St. Clair.....	1,979	2,389	14,240
Detroit River......	3,806	4,295	23,894
Lake Erie..........	534	746	3,722
Municipalities......	1,337	494	3,327
Industries..........	....	788	7,436
Total......	9,438	12,056	62,594

Chapter III

GENERAL DESCRIPTION

The Lake Huron-Lake Erie section comprises the drainage basins of the St. Clair River, Lake St. Clair, and the Detroit River with their various tributary streams. The entire basin contains an area of 8,421 square miles or about 3 percent of the total drainage area of the Great Lakes System. It is divided almost equally between the United States and Canada, with 4,093 square miles in the State of Michigan and 4,328 square miles in the Province of Ontario. The locations of these lakes and streams are shown in figure 1. Physical characteristics and descriptive features are discussed herein.

The St. Clair River and Tributaries

The St. Clair River is the connecting waterway between Lake Huron and Lake St. Clair, flowing in a southerly direction from Lake Huron. This river drains a total of 1,414 square miles, of which 1,311 are in the United States and 103 in Canada. The stream is about 40 miles long. The river has two characteristic sections, the upper or normal channel, and the lower or delta-like portion. The upper channel extends from Lake Huron to Algonac, a distance of about 28 miles. Below Algonac the river divides into several branches to form the delta portion commonly known as the St. Clair Flats. The branch used for navigation is called the South Channel. The International Boundary passes through this channel. Depths in the upper portion of the river vary from 25 to 75 feet. Navigable depths in the South Channel vary from 25 to 45 feet. The mean fall of the stream from Lake Huron to Lake St. Clair is slightly over 5 feet.

The principal tributaries draining into the St. Clair River are the Black, Pine, and Belle Rivers, all of which enter on the United States side. The largest of these is the Black River, draining an area of 690 square miles. From its source in the north central part of Sanilac County it flows southeasterly across Sanilac and St. Clair Counties to its mouth at Port Huron. The main stem of the Black River is about 60 miles long and falls about 200 feet from its source to the mouth. The river has been improved by dredging a channel which extends from the mouth to the Grand Trunk Western Railroad bridge, a distance of 8,200 feet. This channel varies in width from 160 feet at the lower end to 75 feet at the upper end. A settling basin or channel, 75 feet wide, has been dredged for a distance of 2,300 feet upstream from the bridge. Surveys made in 1947 indicate controlling depths of 19 feet from the mouth to 600 feet above the railroad bridge. This entire section is subject to shoaling and requires dredging for maintenance. Above these improvements the Black River is navigable only for small craft.

An artificial canal was constructed in 1912 between Lake Huron and the Black River to provide flushing and diluting water for relieving nuisance conditions in the lower Black River. This canal is about 6,000 feet long, 50 feet wide, and 8 feet in depth. In 1930, backwater gates were installed at the Lake Huron end to prevent a reversal of flow into the lake resulting from flood or other unusual conditions in the Black River.

The Pine River empties into the St. Clair River at the Village of St. Clair, Michigan. A channel 100 feet wide and 13 feet deep has been dredged for a distance of 2,500 feet above the mouth, and thence 75 feet wide and 11 feet deep for a further distance of 3,300 feet, or a total of 5,800 feet. Although no dredging has been done since 1899, a survey made in October 1944 showed a controlling depth of 9 feet for a distance of 3,000 feet above the mouth, gradually decreasing to 3 feet at a point 10,000 feet above the mouth. The lower sections of the stream are used mainly by vessels transporting sand and gravel.

The Belle River flows into the St. Clair River near the southerly limits of Marine City, Michigan. Originally a channel, with depths varying from 14 feet at the lower end to 13 feet at the upper reaches, was dredged for a distance of 5,400 feet above the mouth. Although no dredging operations have taken place since 1899, soundings made in October 1947 showed a controlling depth of 8 feet in the lower portion, which decreased to 5 feet in the upper portion of the dredged section. This stream is used almost exclusively as a winter harbor for vessels of medium size.

Lake St. Clair and Tributaries

The St. Clair River discharges into Lake St. Clair, which lies between Lake Huron and Lake Erie and is the smallest in the Great Lakes chain. The lake is a shallow basin, with low, marshy shores and gently sloping bottom. The maximum natural depth is about 21 feet. A dredged channel, 700 to 800 feet wide and 25 feet deep, extends from the outlet of the South Channel of the St. Clair River southwesterly across the lake to the head of the Detroit River, a distance of about 17 miles. The surface area of the lake, at mean water datum of 574.7 feet, is 430 square miles. Of the total 5,009 square miles of drainage area, 996 lies in the United States and 4,013 in Canada. There are no large commercial establishments, industrial communities, or large harbors located around the lake. In addition to the St. Clair River, the lake receives the flow from the Clinton River on the United States side and the Chenal Ecarte and the Thames, Sydenham, Ruscom, and Belle Rivers on the Canadian side.

Two dumping grounds for dredged material have been established in United States waters at the southwest corner of Lake St. Clair, one on each side of the navigation channel. The larger dumping area starts 2 miles east of Windmill Point and extends into the lake for a distance of 4 miles between the east edge of the ship channel and the International Boundary. The area is irregular in shape and has a maximum length of 9,500 feet. The smaller dumping area lies between the ship channel and the United States shore. It is rectangular in shape, about 2 miles long and 1,000 feet wide.

The Clinton River is the largest United States tributary to Lake St. Clair. It drains an area of about 760 square miles. Its origin is in Bushman Lakes in upper Oakland County. It flows southwesterly to Pontiac, northeasterly to the Oakland-Macomb County line, and then southeasterly into the west side of Anchor Bay, about 2 miles north of Point Huron. This river is about 50 miles long and falls about 425 feet between the source and the mouth. A dredged channel, 8 feet deep and 80 to 100 feet wide, extends from the mouth upstream to Mt. Clemens, a distance of about 8 miles. The most recent dredging operations took place in 1916 on the main river and in 1938 at the entrance channel in Lake St. Clair. Surveys made in October 1947 showed the controlling depth to be 5 feet for a distance of about 5 miles above the mouth. This gradually reduces to 3 feet in the next 2 miles. Vessel traffic on the stream is limited to shallow draft scows, tugs, fishing boats, and recreational craft.

The Chenal Ecarte, on the Canadian side, is a natural channel between the St. Clair River and Lake St. Clair. It branches from the main channel of the St. Clair River below Port Lambton and flows in a southeasterly and then southerly direction for a distance of about 18 miles to its mouth in Mitchell Bay. The stream is navigable for vessels having drafts up to 18 feet, and it provides access to the Sydenham River from the St. Clair River.

The Sydenham River consists of two main tributaries, the North Branch and the East Branch. The North Branch rises in Warwick Township, Lambton County, and thence flows in a southwesterly and southerly direction for about 50 miles. The East Branch originates above Strathroy, in Middlesex County, and flows in a southwesterly direction a distance of over 80 miles to its confluence with the North Branch above Wallaceburg, Ontario. The main stream then flows southwesterly about 5 miles where it joins the Chenal Ecarte at a point about 8 miles above Lake St. Clair. The Sydenham River drains an area of about 1,050 square miles. The total fall is about 192 feet. The stream is navigable for vessels of 14-foot draft for a distance of 4 miles, from the Chenal Ecarte to Wallaceburg.

The Thames River, draining an area of about 2,135 square miles, is the largest of the streams tributary to Lake St. Clair. The headwaters rise in two branches, one near Mitchell and the other near Stratford. The stream flows in a southwesterly direction for a distance of about 170 miles to its mouth at the southeast corner of Lake St. Clair. An approach channel, approximately 8,100 feet long and 100 feet wide, has been dredged across the shallows in Lake St. Clair. This dredging was completed in 1947 and provides a controlling depth of 10 feet. A channel 11 feet deep has been dredged from the mouth to the city of Chatham, about 20 miles upstream. The river is navigable for 5-foot draft to Louisville, about 7 miles above Chatham.

The Belle and Ruscom Rivers are the principal tributaries discharging into the south portion of Lake St. Clair. They originate in Gosfield North Township and flow in a northerly direction to the lake. The mouth of the Belle River is at the village of Belle River, Ontario. The Ruscom River discharges about 5 miles east of the Belle River.

The Detroit River and Tributaries

The Detroit River is the outlet for Lake St. Clair. It begins at Windmill Point and flows in a westerly and then southerly direction for a distance of about 31 miles to its mouth at Lake Erie. The river drains an area of 1,998 square miles, of which 1,786 are in the United States and 212 in Canada. The upper 13 miles of the stream, above Fighting Island, has an unbroken cross section with an average width of 2,400 feet, except at its head where it is divided by Peach Island and Belle Isle. The southerly or lower portion broadens out and is characterized by many islands and shallow expanses. The two largest islands are Fighting Island and Grosse Ile. The former lies in Canadian waters opposite Ecorse and Riverview. Grosse Ile extends from Wyandotte to Gibraltar in United States waters. There are several smaller islands, with large areas of marsh land, located throughout the river. The mean fall of the river from Lake St. Clair to Lake Erie is 2.8 feet. In the upper river the bottom is earth formation, while the lower river consists of earth and boulders, with the exception of a section of bedrock and boulders beginning opposite Bois Blanc Island and extending south towards Lake Erie. The banks are steep in the upper river but are gently sloping in the lower portion.

Although there are no designated dumping grounds in the Detroit River, the area north of Fighting Island, in United States waters, is presently being used by the U. S. Corps of Engineers for disposal of material dredged from the lower Rouge River.

The Rouge River, on the United States side, drains an area of 467 square miles. It rises in Oakland County, flows southwesterly into Wayne County and then southeasterly into the Detroit River. The main stream is approximately 32 miles long and falls about 360 feet from its headwaters to the mouth. The lower 3½ miles, through the Short-Cut Canal, consists of a dredged channel for use of vessel traffic serving the industries in the area. Controlling depths approximate 20 feet for a middle channel width of 120 feet. The Short-Cut Canal is an artificial connection, 3,000 feet long, from the Detroit River to a bend in the Rouge River. This eliminates an "S" shaped curve in the lower Rouge River and shortens the distance to upstream points by about one mile.

The Huron River basin has an area of 1,043 square miles. Its source is in Big Lake in Oakland County, Michigan, and it flows southwesterly through Washtenaw County, then southeasterly through several intermediate counties to its mouth north of Pointe Mouillee. It is about 80 miles long and falls about 440 feet from headwaters to mouth. The major part of its drainage reaches the main stream above Ann Arbor, and from this point downstream it receives no important tributaries. No maintenance dredging operations are carried on in this stream.

Lake Erie – West End

In addition to the Detroit River two major streams empty into the west end of Lake Erie. The Raisin River, entering at Monroe, Michigan, drains an area of 1,125 square miles. The Maumee River drains an area of 6,720 square miles and enters the lake at Toledo, Ohio. The two cities are approached by dredged channels. The west end of Lake Erie is relatively shallow. The shore is gently sloping, and there is extensive marsh land.

A tabulation of the principal drainage areas from Lake Huron to Lake Erie is given in table 3.

TABLE 3—PRINCIPAL DRAINAGE AREAS—
LAKE HURON TO LAKE ERIE

Stream or Lake	Drainage Area in Square Miles		
	United States	Canada	Total
St. Clair River	1,311*	103*	1,414*
Black River	690		
Lake St. Clair	996*	4,013*	5,009*
Clinton River	760		
Sydenham River		1,050	
Thames River		2,135	
Detroit River	1,786*	212*	1,998*
Rouge River	467		
Huron River	1,043		
Totals	4,093*	4,328*	8,421*

*Includes drainage area of all tributaries.

Topography

The drainage area of the Lake Huron-Lake Erie section extends in a north and south direction along both sides of the International Boundary. The topography is characterized by gradually rising terrain from the main waters to the headwaters of the tributary streams. Mean water elevations, referred to mean tide at New York, are 579.8 feet for Lake Huron, 574.7 feet for Lake St. Clair, and 571.9 feet for Lake Erie. The ground elevations range up to about 800 feet in the St. Clair and Detroit River basins. The valleys of the tributary streams in Michigan are generally broad and flat up to the headwaters. Beyond the headwaters the terrain rises quite sharply to the maximum altitude. In Ontario the valleys of the tributaries are long and narrow, but the terrain also rises quite sharply from the headwaters to the maximum elevations.

Geology

The bedrock of this area consists essentially of sedimentary rocks laid down during the Devonian Period of the Paleozoic Era. These sedimentary rocks are principally limestones, shales, and sandstones, with some conglomerates. The thickness of the beds varies from 200 to 1,700 feet. A glacial and post-glacial drift mantle overlies these rock beds throughout the area. It varies in thickness up to 600 feet and is responsible for much of the smoothness of the ground surface of the region. While the surface in general is smooth or broadly rolling, it is broken here and there by low morainic accumulations and by beach ridges of former lakes.

Extensive beds of rock salt underlie the entire area on both sides of the International Boundary. In Michigan the beds are generally continuous from Trenton to Port Huron, but the salt does not form a continuous sheet or bed in Ontario. The band is narrow in width in the lower Detroit River, widening as it extends northward toward the upper St. Clair River. The beds lie over 2,000 feet below the surface in the northern portions. The depth of cover decreases to about 1,000 feet in the southern sections. The thickness of the salt beds generally varies between 100 and 300 feet but reaches almost 700 feet in the central regions. Throughout the area the beds are stratified by dolomitic sediment and shale.

Climate

The climate of this section is one of considerable variation since it lies in the pathway of storms that sweep across the lake region. It is, however, modified to a certain extent by the influence of the surrounding lakes. Sub-zero temperatures occur during January and February, but the winter cold is generally less severe than in regions not affected by such large bodies of water. The lower winter temperatures occur in the elevated areas of the northern portions.

During winter months temperatures are sometimes low enough to cause the formation of a solid ice cover in most sections of these waters. Ice forming along the shores of Lake Huron is broken free by winds or other forces and enters the St. Clair River in large floes. The ice begins to jam in the narrow reach of the river below the village of St. Clair. Additional floes wedge into this jam and form a barrier which at times extends as far upstream as the Black River. The ice jams frequently persist until broken in the spring by tugs or explosives. A solid ice cover at times extends from above Roberts Landing down through the St. Clair Flats to the lower end of Lake St. Clair.

Currents in the Detroit River are generally sufficient to prevent the formation of a solid ice cover. Ice forms near the shores along the entire stream. Occasionally, ice floating down from Lake St. Clair has partially blocked the United States channel upstream from Belle Isle. A complete bridging of the mouth of this channel has been observed, with the result that subsequent ice floes were diverted to the main channel between Belle Isle and Canada. Numerous ice patches or fields occur in the lower section of the river.

Precipitation is well distributed throughout the year but is somewhat greater during the spring and summer than during other seasons. Snowfall is heaviest in the northern parts of the area, the accumulated depth sometimes reaching 2 to 3 feet. Elsewhere snowfall is less and is soon melted by warm or rainy weather. During many winters the ground is bare of snow for a part of the season. The prevailing winds are from the southwest, with an average hourly velocity of 10 to 12 miles. A maximum velocity of 67 miles per hour has been recorded.

Data on temperatures, precipitation, and winds for selected stations are given in table 4.

Population

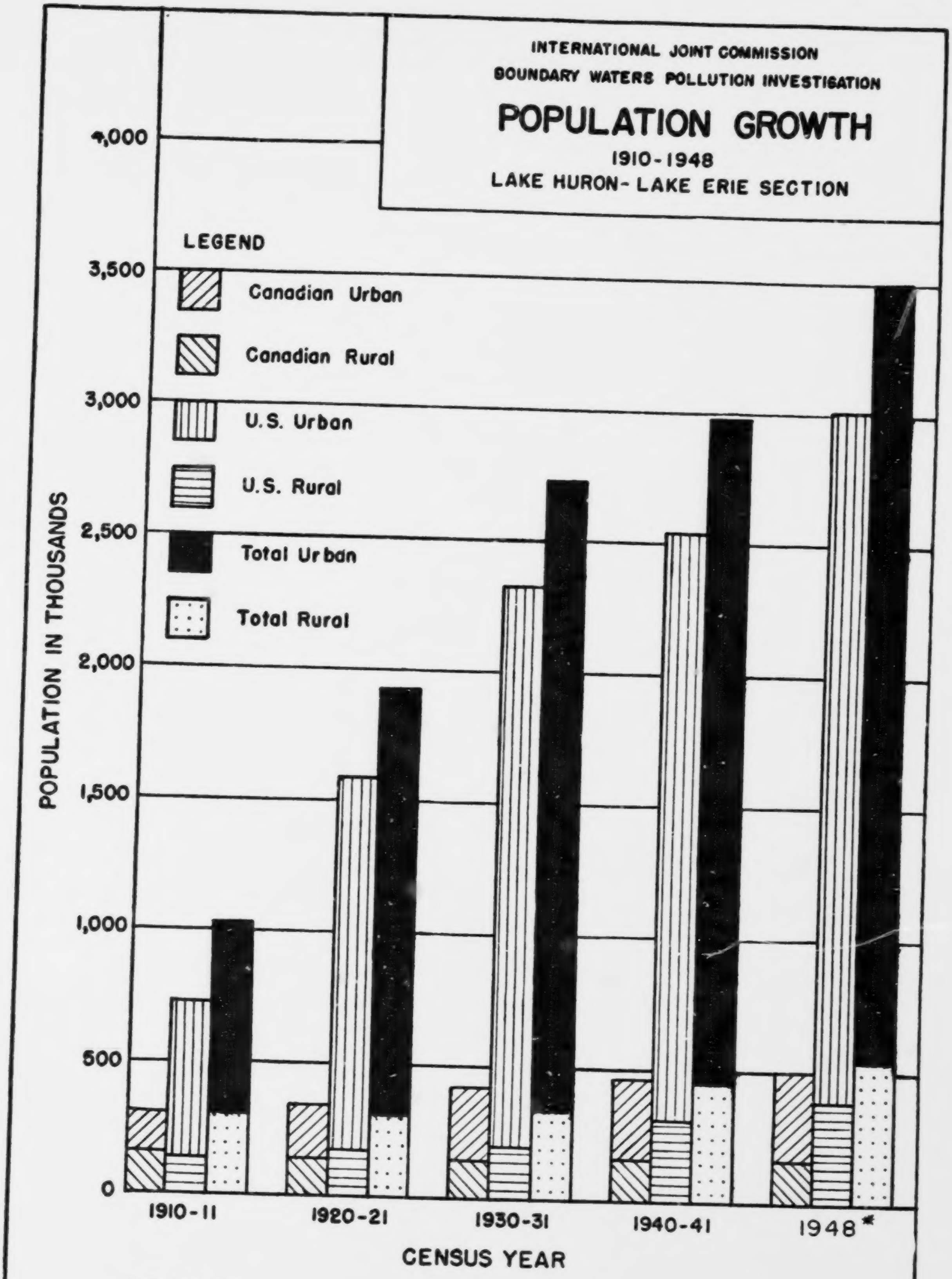
The population in the area, based on the census years of 1940 and 1941, totalled approximately 2,975,000. Estimates made in 1948 indicate the population to be about 3,487,000. In 1948 the population was classified as 15 percent rural and 85 percent urban. For purposes of this investigation, municipalities having populations under 1,000 have been classified as rural and those over 1,000 as urban. Figure 2 shows the growth of population from 1910 to 1948. The major increase during this period occurred in the urban population on the United States side.

The southern part of the area is more thickly populated, containing such large cities as Detroit, Wyandotte, and Windsor. Population changes for the entire Lake Huron-Lake Erie section and for

TABLE 4—CLIMATOLOGICAL DATA FOR SELECTED STATIONS

From Period of Record to 1947, Inclusive

Station	Temperature—Degrees F.				Precipitation—Inches				Wind		
	Yrs. of Record	Annual Average	Maximum	Minimum	Yrs. of Record	Average	Maximum	Minimum	Yrs. of Record	Av. Vel. M.P.H.	Prevailing Direction
Goderich, Ont	31	45	95	—14	45	28.36	....	....	16	9.8	SW
Port Huron, Mich	73	46.4	104	—25	72	29.35	41.96	19.82	62	....	SW
Wallaceburg, Ont	30	47	....	....	30	27.12	....	....	....	....	....
Mt. Clemens, Mich	48	48.0	106	—24	49	28.12	38.17	19.30	47	....	SW
London, Ont	54	46	....	....	54	38.17	....	....	....	....	....
Detroit, Mich	73	48.7	104	—24	77	31.47	47.69	21.06	65	11	SW
Windsor, Ont	47	48	....	....	47	31.12	....	....	5	10.3	SW
Monroe, Mich	31	49.9	106	—21	31	30.38	41.41	20.97	41	....	SW
Pelee Island, Ont	36	49	....	....	36	29.50	....	....	....	....	....



* Estimated

Data from Canadian and U.S. Census Bureaus

Figure 2

TABLE 5—DISTRIBUTION OF POPULATION BY DRAINAGE BASINS, 1940-1941 AND 1948

Drainage Basin	Michigan			Ontario			Combined		
	Urban	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
1940-1941									
St. Clair River	47,500	43,600	91,100	3,300	18,700	22,000	50,800	62,300	113,100
Lake St. Clair	121,500	190,200	311,700	134,700	161,300	296,000	256,200	351,500	607,700
Detroit River	128,700	1,997,000	2,125,700	15,400	113,100	128,500	144,100	2,110,100	2,254,100
Totals	297,700	2,230,800	2,528,500	153,400	293,100	446,500	451,100	2,523,900	2,975,000
1948									
St. Clair River	60,200	47,500	107,700	2,800	24,400	27,200	63,000	71,900	134,900
Lake St. Clair	161,100	239,600	400,700	128,300	180,900	309,200	289,400	420,500	709,900
Detroit River	160,400	2,333,800	2,494,200	17,600	130,000	147,600	178,000	2,463,800	2,641,800
Totals	381,700	2,620,900	3,002,600	148,700	335,300	484,000	530,400	2,956,200	3,486,600

TABLE 6—POPULATION CHANGES IN PRINCIPAL MUNICIPALITIES

Municipality	1910-1911	1920-1921	1930-1931	1940-1941	1948 (Estimated)
Lake Huron-Lake Erie Basin	1,024,600	1,929,600	2,734,000	2,975,000	3,486,600
Port Huron, Mich	18,863	25,944	31,361	32,759	38,900
St. Clair, Mich	2,633	3,204	3,389	3,471	4,100
Marine City, Mich	3,770	3,731	3,462	3,633	4,300
Mt. Clemens, Mich	7,707	9,488	13,497	14,389	22,300
Detroit, Mich	465,766	993,678	1,568,662	1,623,452	1,888,200
Wyandotte, Mich	8,287	13,851	28,368	30,618	37,700
Sarnia, Ont	9,947	14,877	18,191	18,731	23,000
Wallaceburg, Ont	3,438	4,006	4,326	4,986	6,900
Windsor, Ont	23,433	55,935	98,179	105,311	119,600
Amherstburg, Ont	2,560	2,769	2,759	2,853	3,300

the principal municipalities from 1910 to 1948 are given in tables 5 and 6. The population density, based on the 1948 figures and expressed as persons per square mile, was about 700 for Michigan, 110 for Ontario, and 400 for the entire area.

Land Use and Development

The Lake Huron-Lake Erie section is devoted chiefly to agricultural, industrial, and recreational uses. The northern part, except for the Port Huron-Sarnia district, is used for farming, while that in the south is used for industrial purposes. Recreational facilities, such as summer cottages, fishing areas, and bathing beaches, are distributed throughout the region. There is little forest land. The forests are mainly small isolated woodlots, and these probably have little or no effect upon the flow or quality of the streams.

The agricultural areas consist of relatively small, individually-owned farms. In some sections as much as 90 percent of the acreage is used for this purpose. Chief products are field crops, vegetables, and fruits. There are also large yields of dairy and poultry products.

The automobile industry has been mainly responsible for the rapid industrial growth in the lower part of the section during the past 30 years. This industry has brought about the development of many related activities such as steel mills, blast furnaces, tool and die manufacturing, and coke plants. Other prominent industries include chemical plants, pulp and paper mills, distilleries, oil refineries, and rubber processing plants. In the Sarnia area rapid industrial expansion occurred during World War II. Oil refineries, synthetic rubber plants, and chemical plants were built or expanded during this period. The widespread use of contiguous areas for agricultural purposes has resulted in the establishment of many food processing plants such as canneries, dairies, and beet sugar refineries, especially in the upper and central portions of the Lake Huron-Lake Erie section.

Considerable use has been made of many of the islands, for both industrial and recreational purposes. Zug Island, Fighting Island, and the upper end of Grosse Ile are being used for the disposal of waste materials produced by the manufacture of caustic soda and soda ash. The islands of the St. Clair Flats are used for summer camps, hunting, and fishing centers. Belle Isle and Bois Blanc Island are confined to recreational purposes.

Bathing has been prohibited in the waters around Bois Blanc Island for the past few years.

The largest concentrations of summer residences are situated on both shores of the St. Clair River and Lake St. Clair and on the Canadian shore of the lower Detroit River. Bathing beaches are available principally on the west shore of Lake St. Clair and on Belle Isle, in the Detroit River. Wildlife habitats are located throughout the region, the important ones being in the St. Clair Flats, Mitchell Bay, Bar Point, and Pointe Mouillee areas. Although there is little or no commercial fishing, there is a considerable amount of sport fishing, in both winter and summer. Statutes of the State of Michigan prohibit the setting of nets on the United States side of the connecting waters between Lake Huron and Lake Erie. The St. Clair River and Flats and the Lake St. Clair areas enjoy a wide reputation for bass, pickerel, muskellunge, and perch fishing.

Chapter IV

HYDROMETRIC DATA

Hydrometric data on a watercourse can be used to evaluate the effects of flow, currents, distribution into channels, and other related factors which influence stream pollution. In the Lake Huron-Lake Erie section large volumes of water, strong and variable currents, and numerous channels transport and dilute the incoming waste discharges. Pollutants which are highly concentrated at the point of discharge may become greatly diluted in certain areas and may remain concentrated in others. Even these dilute quantities may be carried long distances and cause objectionable conditions in the boundary waters. Pollution is important at its immediate point of discharge. The degree of its subsequent importance will be influenced by the time of flow, volume, intermingling, and other stream characteristics.

A detailed knowledge of river and lake currents is essential in determining transboundary travel of polluted waters.

Sources of Information

Hydrometric data presented in this report were obtained from studies made in the field by the Commission's staffs and from available records and reports of various other governmental agencies.

Flow records for the connecting waters between Lake Huron and Lake Erie were furnished by the U. S. Lake Survey. These long term records yielded information suitable for the purpose of this investigation. Discharge records at the mouths of the tributary streams emptying into these waters were inadequate. Supplementary data were secured by establishing gaging stations on the larger United States tributaries under a cooperative agreement between the U. S. Geological Survey and the International Joint Commission. These gaging stations were maintained from June 1947 to July 1948. Thus reliable records were available for a short time only.

Information on the course of pollution, particularly with reference to its crossing the boundary, was obtained from float studies made by the field staffs. The city of Detroit also made available to the Board the results of independent studies on current behavior.

Flow Characteristics

Information on the flow characteristics of the St. Clair River, Lake St. Clair, Detroit River, and tributaries are considered separately for each area.

St. Clair River

The flow in the St. Clair River during the 48-year period, 1900-1947, has averaged 174,000 c.f.s. The river has a mean velocity of about 5 miles per hour near its upper end in the vicinity of the Blue Water Bridge. In the lower reaches, through the South Channel, the velocity is about 2 miles per hour. At intermediate points the velocity varies irregularly between these limits.

Two islands, both in Canadian waters, split the flow in the section above Algonac. Stag Island, located about 9 miles below Lake Huron diverts approximately 64 per cent of the total river flow to the United States side of the island. Woodtick Island, situated about 22 miles below Lake Huron, diverts 83 percent of the total flow to the United States side of the island. The International Boundary is established at approximately midstream throughout this section of the river.

The St. Clair River enters Lake St. Clair through six channels. Information as to the flow in the several channels is based on current meter measurements made by the U. S. Lake Survey in 1910. Check measurements, made in 1947, indicate only minor changes in the distribution of flow since 1910. The distribution of total river flow through each channel, under average discharge conditions, is given in table 7.

TABLE 7—DISTRIBUTION OF FLOW—LOWER ST. CLAIR RIVER CHANNELS

Channel	Average River Flow	
	% of Total	c. f. s.
Chenal Ecarte	6.0	10.400
Bassett Channel	6.2	10,800
Chematogan Channel	0.3	500
South Channel	30.0	52,200
Middle Channel	17.5	30.500
North Channel	40.0	69,600

These data show that approximately 87.5 percent of the St. Clair River flow enters the northwestern section of Lake St. Clair through the North, Middle, and South Channels. Only 12.5 percent enters the much larger portion of the lake on the Canadian side of the International Boundary through the three smaller channels.

On occasion the flow in the St. Clair River has been affected by wind action on Lake St. Clair, by a reversal of flow from the Detroit River, and by ice jams. The first two of these conditions are generally of short duration, whereas the reduction of flow by ice jams has lasted as long as one month and has at times been as great as 50 percent.

Lake St. Clair

In addition to the average discharge from the St. Clair River of 174,000 c.f.s., Lake St. Clair receives an average inflow of approximately 2,300 c.f.s. from the major tributaries listed in table 3.

At the mean stage of 574.7 feet, Lake St. Clair has an average depth of 10 feet and holds approximately 120.4 billion cubic feet of water. If there were complete and uniform displacement of the lake water by the St. Clair River flow alone it would take 8 days, under average conditions, for the incoming water to reach the Detroit River. Actually, flow conditions are influenced by those factors which have been discussed previously, and therefore the theoretical displacement time is not attained. From observations made in two instances it was found that time of passage through Lake St. Clair was between 5 and 7 days. Other observations have indicated periods up to 16 days.

Information on the currents in Lake St. Clair is incomplete and approximate. The several float studies have produced enough data, however, for an approximate analysis of the nature of these currents.

Floats released in the narrow opening from Anchor Bay into the main part of the lake were carried in a southerly direction by relatively fast currents varying between 0.4 and 0.9 f.p.s. As the flow through Anchor Bay moves south below Point Huron it merges first with the flow from the Middle Channel and later with the flow from the South Channel. Below Point Huron, the direction and velocity of the combined current are influenced primarily by the variable winds. From this area to the head of the Detroit River the rate of travel, as determined by depth floats, varied between 0.18 and 0.47 f.p.s. On the west side of the ship channel a slight tendency toward a clockwise movement of existing currents was noted.

Measurements made by the U. S. Lake Survey indicated a mean velocity of 1.5 f.p.s. at the mouth of the South Channel and 0.9 f.p.s. in the St. Clair Flats, 1¼ miles below. No measurable current (less than 0.4 f.p.s.) could be detected with current meters 2¼ miles below the mouth of the South Channel. A float placed at this same point indicated a slight current parallel to the ship channel, toward the Detroit River.

Observations made during the several float studies provided additional information as to the effects of wind on the currents in the western sector of the lake. It was observed that with no measurable wind, or a wind from the northeast, currents moved in a southwesterly direction in the area between Point Huron and Gaukler Point. With winds from the northwest or southwest, currents moved in a southeasterly direction and crossed the International Boundary before they were diverted into the funnel-shaped approach to the Detroit River.

The relatively small flow from the St. Clair River, entering the lake on the Canadian side of the boundary, induces a slow movement of water in a southeasterly direction under the prevailing southwest wind or a wind from the northwest. Definite conclusions on current movements for specific dates cannot be reached, however, without consideration of wind direction and intensity.

No studies have been made of the lake currents under ice cover. Conclusions regarding the direction and velocity of the currents under ice are based on meager observations and reasonable interpretations. It is apparent that the water should follow a more direct course than during the months when the lake is exposed to wind action. It may be further deduced that the ice covering on such a shallow basin adds resistance to the flow. At the opening into the lake from Anchor Bay the ice sheet reduces the cross-sectional area and increases the velocity of this incoming major current. To overcome such resistance to flow the water level in Anchor Bay has been, at times, appreciably higher than at points at the lower end of the lake.

Detroit River

Discharge data, compiled by the U. S. Lake Survey, for the 13 year period 1936-1948 show the average flow in the Detroit River to be about 177,000 c.f.s. At the head, approximately 70 percent of the total flow passes to the United States side of the boundary through the larger channel between Windmill Point and Peach Island, and only 30 percent passes between Peach Island and the Canadian shore. Below Peach Island the river flow is so divided by Belle Isle that there is a boundary cross-over, which results in 70 percent of the total flow passing between Belle Isle and the Canadian shore. The current in the section of the river from the foot of Belle Isle to the head of Fighting Island is 1.5 miles per hour.

At the head of Fighting Island the river divides into three channels. Measurements made in 1948 showed that approximately 21 percent of the total river flow passes down the channel east of Fighting Island. Fighting Island Channel, which lies west of this island and is the main vessel route, carries about 52 percent of the river flow. The channel west of Grassy Island and surrounding shoals carries the remaining 27 percent of the total flow.

Point Hennepin on Grosse Ile divides the flow in the channel lying west of Grassy Island into two branches. One branch continues through to Lake Erie as the Trenton Channel, the other rejoining the main central ship channel. The Trenton Channel carries about 24 percent of the total river flow. East of Grosse Ile the river is divided into two principal channels, both of which are used for vessel traffic. The Livingston Channel carries about 26 percent, and the Amherstburg Channel about 44 percent of the river flow. Opposite Amherstburg the average current velocity is 2 miles and the maximum velocity about 4 miles per hour.

A summary of the percentage distribution of flow through the channels where measurements have been made is given in table 8, as prepared by the U. S. Lake Survey.

TABLE 8—DISTRIBUTION OF FLOW—DETROIT RIVER CHANNELS

(Based on Total Flow of 177,000 c.f.s.)

Channel	1930		1933		1944		1948	
	%	c. f. s.	%	c. f. s.	%	c. f. s.	%	c. f. s.
Belle Isle—U. S. Side					30.9	54,750		
Fighting Island							52	92,040
Grassy Island—U. S. Side							27	47,790
Fighting Island—Canadian Side					21.7	38,430	21	37,170
Trenton Channel	22.6	39,940	24.6	43,560	23.5	41,580		
Upper Livingston Channel	19.9	35,300			26.2	46,410		
Amherstburg Channel	28.8	51,060	41.9	74,200	34.6	61,280		

Tributaries

Tributaries of the St. Clair River, Lake St. Clair, and Detroit River carry a small total flow in comparison with that of the main watercourses. This comparison holds for average conditions rather than for those occurring under variable flood discharges.

An unusual tributary situation, however, is found with respect to flow in the Rouge River. The natural flow is supplemented by substantial volumes of municipal and industrial wastes discharging into the lower reaches. The average combined flow for the period of record was approximately 1,100 c.f.s., of which 650 c.f.s. or 59 percent was contributed by these wastes. Only 450 c.f.s. of the total flow was the natural drainage from the watershed.

A summary of the stream discharge data for the principal tributaries to the St. Clair River, Lake St. Clair, and Detroit River, as compiled from the records of the U. S. Geological Survey and the Water and Power Bureau of Canada, is given in table 9.

Flow Reversals

Under normal conditions the drop in the water level from Lake St. Clair through the Detroit River to Lake Erie is approximately 3 feet. Occasionally, substantial changes in barometric pres-

TABLE 9—TRIBUTARY DISCHARGES—LAKE HURON-LAKE ERIE SECTION

Tributary	Location of Gaging Station	Period of Record	Discharge, c. f. s.		
			Average	Maximum	Minimum
Black River	Near Fargo, Mich	1944-1948	336	14,400	1.8
Mill Creek	Near Abbottsford, Mich	1947-1948	138	2,360*	11
Clinton River	½ mile west of Mt. Clemens, Mich	1934-1947	452	21,200	50
Sydenham River	At Alvinston, Ont	1947-1948	211	3,710	8
Thames River	At Thamesville, Ont	1938-1943		26,220	
	At Byron, Ont	1922-1931	1,260		
		1938-1943		31,160	
Rouge River	At Outer Drive, Dearborn, Mich	1930-1948	97.4	13,000	2.7
Middle Rouge River	Near Garden City, Mich	1930-1933		1,560*	1.4
		1947-1948	94.6		
Lower Rouge River	At Inkster, Mich	1930-1933		1,520*	0.3
		1947-1948	63.2		
Rouge River	Above Zug Channel, Detroit, Mich. (Est.)	1947-1948	450†		
Huron River	At Barton, Mich	1914-1947	391	5,840*	4.0

*Represents maximum daily average.

†Does not include municipal and industrial plant discharges.

sures and strong sustained winds from the east build up the water level at the western end of Lake Erie to a height as great as 8 feet above the water level at Buffalo, New York, and eliminate the differential in water elevations between Lake Erie and Lake St. Clair. At times the water level of Lake Erie, at the mouth of the Detroit River, has been even higher than the water level in Lake St. Clair.

When the water at the west end of Lake Erie is high normal downstream currents of the Detroit River are retarded, and the discharge is diminished gradually. Depending upon the intensity and duration of the wind from the east or northeast, lake water could be pushed progressively up the river until the flow was so retarded that the gradient would be reversed. It follows that after equilibrium is reached in the Detroit River, if the winds continue strong enough to raise the water level in Lake Erie above the level in Lake St. Clair at least a partial reversal of flow in the river will occur. No data are available to indicate the length of time in hours that the elevation of Lake Erie must exceed the elevation of Lake St. Clair to develop a substantial reversal of flow.

Records of the U. S. Lake Survey show thirteen instances between 1911 and 1948 when the water levels at Amherstburg or Gibraltar exceeded those at Fort Wayne, in Detroit. In nine of these instances the lower river elevations were higher than Lake St. Clair. In all these cases the high water at the mouth of the Detroit River was preceded by strong winds from the east or northeast. On five occasions the water level at the river mouth fell and then rose a second time so that normal elevations were reversed twice in an interval of less than 2 days. During these reversals the water level in Lake Erie at the mouth of the Detroit River exceeded that in Lake St. Clair by a maximum of less than one foot, except for two extreme instances when the difference reached 1½ feet. The differences noted are approximate because the Lake St. Clair gages were read only three times a day, and therefore readings may not always have corresponded to the peak of the gradient reversal. The data show that reversal of the normal water level has continued over periods ranging from 2 to 12½ hours. This phenomenon has been noted by trained observers on several occasions during the recent years of record.

Transboundary Currents

The behavior of current action in the boundary waters of the Lake Huron-Lake Erie section was studied by the field staffs during the summers of 1947 and 1948. Two independent studies were made employing small wooden surface floats and sub-surface floats. Each study provided mutually supporting data to show that definite crossing of currents from one side of the International Boundary to the other occurs at various locations.

In the St. Clair River surface floats crossed from the upper sections on the Canadian side to the lower section on the United States side, some floats continuing through the North Channel and into Anchor Bay and others via the South Channel into Lake St. Clair. Floats released on the United States side of the upper river were generally carried downstream and crossed to the Canadian side between Courtright and Sombra. The floats, after reaching Lake St. Clair, followed a path along the west shore of the lake, continuing through the Detroit River and into Lake Erie. Many of these floats were observed on both sides of the river and on both shores of the western end of Lake Erie.

A number of sub-surface floats released at or near known sources of domestic and industrial pollution, along both shores in the Port Huron-Sarnia area showed no tendency to cross the International Boundary. The currents were found to follow a course somewhat parallel to the respective shore lines. Some significance may be attached to the fact that the floats submerged to depths of 15 to 20 feet, near the Canadian shore at Port Lambton, travelled down the Chenal Ecarte. Those submerged to shallower depths continued on and followed down the main or South Channel and probably across the boundary.

Current movements in Lake St. Clair are not well defined and depend largely on wind direction. Surface floats released on the west side of the lake, in general, follow paths similar to those carried down from the St. Clair River. In some instances these floats crossed the International Boundary to the Mitchell Bay area. Other floats, released at the mouth of Anchor Bay on the west shore of Lake St. Clair, in the vicinity of Nine-Mile and Martin Drains, travelled to the south shore between the Detroit River and the Belle River in Ontario. Floats released at the east end of the lake did not cross the International Boundary.

Information obtained from sub-surface float studies showed that currents from Anchor Bay merge with those from the South Channel. These currents can be expected to cross the boundary under favorable wind conditions. A strong current moving in a westerly direction along the south shore of Lake St. Clair was also observed at the approach to the Detroit River. Sub-surface floats released in Mitchell Bay showed no perceptible current direction.

Similarly in the Detroit River, surface floats crossed from side to side. In the upper river, floats crossed from the United States side through the opening between Peach Island and Belle Isle to the Canadian side. Several floats released at the mouth of the Rouge River and in the vicinity of the Detroit sewage treatment plant outlet were found on the Canadian shore opposite the upper end of Fighting Island.

Observations with sub-surface floats in the Detroit River were limited to the upper section, from Windmill Point to below Belle Isle. The floats placed less than 1,000 feet off Windmill Point showed no tendency to cross into Canadian waters, but those placed beyond 1,000 feet from the United States shore crossed the boundary between Peach Island and Belle Isle under a variety of wind conditions.

Chapter V

USES OF BOUNDARY WATERS

The importance of boundary water pollution arises from the multiplicity of purposes for which these waters are utilized and the resulting conflict between these uses. Article VIII of the treaty between the United States and Great Britain relating to boundary waters, signed January 11, 1909, states:

> "The following order of precedence shall be observed among the various uses enumerated hereinafter for these waters, and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of precedence:
> (1) Uses for domestic and sanitary purposes,
> (2) Uses for navigation, including the services of canals for the purpose of navigation,
> (3) Uses for power and for irrigation purposes".

This order of precedence is highly significant in that domestic and sanitary purposes, which are so closely related to public health, are given priority over all other uses. It is also significant that other water needs, such as for industry, for recreation, and for the support of fish and wildlife, which have come into prominence in the intervening years, are not specifically cited in the treaty. It is recognized that these waters have now come to serve this expanded category of uses. Irrespective of the uses made, the treaty requires that these boundary waters shall not be polluted on either side to the injury of health or property on the other.

These waters constitute a natural resource which has been developed to a high degree by both countries. The many and variable purposes which they now serve are discussed herein.

Domestic Water Supply

Nearly 3,000,000 people, residing in some 50 communities, use the connecting waters from Lake Huron to Lake Erie as a source of domestic water supply. For this purpose alone, total water pumpage exceeds 425 million U. S. (354 million Imp.) gallons per day. Details of major public water supplies are given in table 10.

These water supplies are taken from various points between Lake Huron and Lake Erie. The intake locations are at various distances from shore, these locations having obviously been dictated by water quality. This means that each supply is subjected to the pollution introduced by upstream communities. By virtue of their locations at the head of these waters Port Huron and Sarnia are the only communities not subjected to this condition. It will be noted in table 10 that practically all these public water supplies are filtered and

TABLE 10—MUNICIPAL WATER SUPPLIES—LAKE HURON-LAKE ERIE SECTION

Municipality	Source	Population Served (Est. 1948)	Daily Consumption M.G.D.	Water Treatment
Port Huron, Mich.	St. Clair River	38,900	12.0*	D
Marysville, Mich.	"	2,400	1.7*	FD
St. Clair and District, Mich.	"	4,500	0.44*	FD
Marine City, Mich.	"	4,300	0.79*	FD
Algonac and District, Mich.	"	2,600	0.31*	FD
Sarnia, Ont.	"	24,000	4.39†	D
Sombra, Ont.	"	2,700	0.27†	D
Wallaceburg, Ont.	"	6,900	0.90†	FD
New Baltimore, Mich.	Lake St. Clair	2,000	0.27*	FD
Fairhaven (Ira Twp.), Mich.	"	1,500	0.20*	FD
Mt. Clemens, Mich.	"	22,300	2.44*	FD
Grosse Pte. Farms, Mich.	"	8,100	1.88*	FD
Highland Park, Mich.	"	57,100	10.8*	FD
Tilbury, Ont.	"	2,000	0.65†	FD
Belle River, Ont.	"	1,200	0.50†	FD
Tecumseh, Ont.	"	3,500	0.72†	FD
Detroit and District, Mich.	Detroit River	2,450,000	365*	FD
Wyandotte, Mich.	"	37,700	4.25*	FD
Windsor and District, Ont.	"	144,300	13.0†	FD
Amherstburg, Ont.	"	2,900	0.53†	FD

*U. S. gallons. †Imp. gallons. D Chlorinated. F Coagulated, Settled, Filtered.

chlorinated. Port Huron and Sarnia again are exceptions, in that they chlorinate only.

Sanitary Purposes

These waters receive the domestic wastes from approximately 2,500,000 persons. A large portion of the water pumped for domestic consumption is used for sanitary purposes and is returned as sewage, either treated or untreated. While sewage is distributed through numerous outlets along the shores, the thickly populated Detroit-Windsor district imposes a heavier load of sewage than in any other area of these waters. The next heaviest contribution occurs in the Port Huron-Sarnia area.

Navigation

Passenger and other vessels navigating the Detroit River, Lake St. Clair, and St. Clair River, or any part thereof, carried nearly 3,000,000 persons during the 1947 season of navigation. Of this total, 1,200,000 were classified as passengers, the others being listed as crew members.

The greatest concentration of vessel commerce occurred in the Detroit River, where total vessel passages exceeded 28,000, representing a net tonnage of 99,000,000. This contrasts with 77,000,000 tons through Lake St. Clair and St. Clair River. The total number of passengers carried on the Detroit River alone was approximately 1,000,000.

The disposal of sewage, refuse, oils, and ballast and bilge waters from vessels assumes importance, especially in restricted areas near sources of public water supply. It may also affect the potable water supply of other vessels.

Power and Irrigation

While power and irrigation purposes are given a place in the order of precedence established by the treaty, there are no hydro-electric power developments or irrigation projects on the Lake Huron-Lake Erie section of the boundary waters.

Industrial Uses

Industry uses boundary waters for process, steam power, cooling, and sanitary purposes in addition to that drawn from public supplies. From available data the water so used by industry, exclusive of steam power plants, amounts to nearly 1,400 M. G. D. (U. S.) Of this, about 1,200 M. G. D. is drawn from the Detroit River and approximately 160 M. G. D. is taken from the St. Clair River. The greatest use of industrial water is centered in the upper St. Clair River and the lower Detroit River.

Most of this industrial supply is returned as wastes directly to the boundary waters, with a minor portion going to municipal sewers. The boundary waters also receive industrial wastes of some magnitude from the principal tributaries. In addition, substantial volumes are drawn from public water supplies and ultimately reach the boundary waters by way of municipal sewers.

Recreational Uses

Extensive use of these boundary waters is made for bathing at numerous points. Three types of bathing beaches, municipal, commercial, and private, operate in this area. While the number of beaches maintained by municipalities is not great they provide recreational facilities for a large segment of the population. These facilities are being expanded. As an example, the Huron-Clinton Metropolitan Authority is establishing a public beach in Lake St. Clair to accommodate 40,000 people. Commercial beaches, operated for the public by private enterprise, are located mostly in Lake St. Clair. Private beaches along the waterfront of residential properties are numerous and widely scattered. Pollution interferes with the development of many sections of the waterfront, which would be otherwise suitable for bathing.

Interest in pleasure boating is widespread in this area. Twenty-five thousand pleasure craft, of 16-foot length or larger, are registered in the Detroit area alone. Innumerable craft of smaller size also ply those waters.

Fish and Wild Life

Fishing in these waters is now carried on principally by sportsmen. The St. Clair River is noted as a habitat for walleyed pike. In Lake St. Clair perch predominate in numbers, but the lake is also considered to be one of the finest fishing grounds for muskellunge. Fishing continues in Lake St. Clair through the winter, and it is not uncommon to observe over 2,000 fishing shanties on the ice. In the Detroit River sport fishing is less significant. The principal catches are perch and walleyed pike.

Commercial fishing in the United States waters of this section has not been permitted since 1909. The yield from commercial fishing on the Canadian side has declined progressively since the early nineties. The average annual amount and value of equipment used and the pounds and value of fish taken by Canadian fishermen from Lake St. Clair and the connecting rivers for the 5-year periods preceding 1914 and 1940, are:

Period	Men Employed	Total Value of All Investment	Total Catch Pounds	Value of Catch
1910-1914........	267	$ 34,104	1,281,722	$ 71,064
1936-1940........	138	42,494	733,405	39,466

Commercial and sport fishing is of greater magnitude in Lake Erie, but even here the yield from commercial fishing in the western end of the lake has declined steadily for the last 25 years.

Certain areas of these waters are natural habitats for many kinds of water fowl and attract many hunters. The marshy shoals of Lake St. Clair and the lower Detroit River, below Fighting Island, are particularly noted for migratory wild fowl. Many of these areas have been leased as private hunting grounds. Two large areas, the St. Clair Flats and Pointe Mouillee, are protected and maintained as public hunting grounds.

Legislation

Administrative authority for remedial measures in pollution control is centered in the legislation enacted by various levels of governments in both countries. The several Federal, state, provincial, and municipal laws applicable to pollution control are discussed herewith.

Federal Legislation—United States

The United States Government now exercises pollution control mainly through four acts of legislation. The first of these is embodied in the provisions of Section 13 of the "Laws for the Protection and Preservation of the Navigable Waters of the United States" as included in the River and Harbor Act, approved March 3, 1899. This law prohibits the deposit of "any refuse matter of any kind or description whatever other than that flowing from streets and sewers and passing therefrom in a liquid state, into any navigable water of the United States or into any tributary of any water from which the same shall float or be washed into such navigable water."

The "Oil Pollution Act of 1924" deals specifically with deposition of oils from vessels into coastal or tidal navigable waters.

The Interstate Quarantine Regulations, Section 72, 121, Part 72, Title 42, Code of Federal Regulations, prohibits the discharge of sewage, ballast or bilge water from vessels while operating on fresh water lakes and rivers within areas adjacent to domestic water intakes, as designated by the Surgeon General of the Public Health Service.

The most recent legislation enacted by the U. S. Government is Public Law 845, known as the "Water Pollution Control Act." This law, enacted June 30, 1948, is designed to "recognize, preserve and protect the primary responsibilities and rights of the States in controlling water pollution, to support and aid technical research to devise and perfect methods of treatment of industrial wastes which are not susceptible to known effective methods of treatment, and to provide Federal technical services to State and interstate agencies and to industries, and financial aid to State and interstate agencies and to municipalities, in the formulation and execution of their stream pollution abatement programs." The authority and responsibility relating to this Act are vested in the Public Health Service and the Federal Works Administration. The Public Health Service shall "in cooperation with other Federal agencies, with State water pollution control agencies, and interstate agencies, and with municipalities and industries involved, prepare or adopt comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof and improving the sanitary condition of surface and underground waters."

Federal Legislation—Canada

There is no Federal legislation in Canada which is concerned with pollution of water per se. There are, however, certain statutes which indirectly deal with the question of pollution and might, under appropriate circumstances, be successfully invoked.

The "Navigable Waters Protection Act," enacted in 1927, prohibits the throwing or depositing of "any sawdust, edgings, slabs, bark or rubbish, of any description whatsoever into any river, stream or other water, any part of which is navigable or which flows into any navigable water." It further prohibits the throwing or deposition of "any stone, gravel, earth, cinders, ashes or other material or rubbish liable to sink to the bottom in any navigable non-tidal waters of Canada where there are not at all times at least eight fathoms of water."

The "Fisheries Act," enacted in 1927, prohibits the discharge of ballast, coal ashes, stones, lime, chemical substances or drugs, dead or decaying fish, and other deleterious substances either on shore, between the high and low water levels, or into "any water frequented by fish, or that flows into such water, nor on ice over either such waters."

The "Migratory Birds Convention Act," enacted in 1927, prohibits the deposit or discharge of "oil, oil wastes, or deleterious substances * * * in any water frequented by migratory wildfowl, or that flows into such water, nor on ice over either of such waters."

Section 5(f) of the "National Health Act" of Canada, enacted in 1944, states that the Minister of National Health and Welfare shall enforce "any rules or regulations made by the International Joint Commission, promulgated pursuant to the treaty * * * so far as the same relate to public health."

The Criminal Code of Canada, Section 221, defines a common nuisance as "an unlawful act or omission to discharge a legal duty, which act or omission endangers lives, safety, health, property or comfort of the public, or by which the public are obstructed in the exercise or enjoyment of any right common to all His Majesty's subjects. R. S., c. 146, s. 221." Appropriate penalties are prescribed for anyone guilty of a common nuisance.

State of Michigan

Act 245, P. A. 1929, as amended by Act 117, P. A. 1949, created a Water Resources Commission "to protect and conserve the water resources of the state, to have control over the pollution of any waters of the state and the Great Lakes, with power to make rules and regulations governing the same, and to prescribe the powers and duties of such commission; to designate the commission as the state agency to co-operate and negotiate with other governments and agencies in matters concerning the water resources of the state; and to provide penalties for the violation of this Act." The Commission consists of the Directors of Conservation, Health, Highways, and Agriculture, as well as three citizens appointed by the Governor, representing industrial, municipal, and conservation groups.

Act 98, P. A. 1913, as amended, gives the State Health Commissioner authority to supervise, visit, and control water works and sewerage systems owned and operated by municipalities or other corporations, partnerships and individuals; to make rules and regulations necessary for their control and operation; to examine and approve plans and issue construction permits for water and sewerage systems and treatment works; to issue orders to correct faulty systems or parts thereof found dangerous to individuals or to the public health generally, provided that no corporation can be deprived of right to dispose of sewage in any river after all deleterious material has been eliminated by filtration.

Act 17, P. A. 1921, makes it the duty of the Department of Conservation to provide and conserve natural resources of the state; to prevent and guard against the pollution of lakes and streams within the state and to foster and encourage the protection and propagation of fish.

Act 350, P. A. 1865, as amended, makes it unlawful for any person to put into the waters of this state any offal, blood, putrid brine, putrid fish, or filth of any description.

Act 316, P. A. 1923, as amended, provides for the construction in rural, suburban and certain urban areas of sewerage and drainage designated as county drains. The Act provides that any county drain may be used for sewage disposal by any city, village, or township for which available. After January 1945 it became unlawful to discharge any sewage or waste material capable of producing in said drain detrimental deposits, objectionable odor nuisance, injury to the drainage conduit or structures, or pollution of the waters of the state receiving the flow from said drain as to injure livestock, destroy fish life or be injurious to the public health, until all deleterious material has been removed. The Act also provides for the construction of disposal plants, filtration beds and other mechanical devices as will properly purify the flow of the drain.

Act 320, P. A. 1927 authorizes counties, cities, and villages, either individually or jointly by agreement to borrow money and issue bonds to own, acquire, construct, equip, operate and maintain intercepting sewers and sewage disposal plants and to make a charge to owners or occupants of the premises for this purpose. It further provides that whenever a court of competent jurisdiction in the State shall have ordered the installation of sewage disposal system and plans have been approved by the State commissioner of health the legislative body shall have authority to issue and sell the necessary bonds for the construction and installation thereof. The amount of such bonds either issued or outstanding shall not be included in the amount of bonds which the municipalities may be authorized to issue under any statutes of this State or charters.

Although these State Acts designate a specific agency as enforcing authority, the inclusion of the head of that agency as a member of the Water Resources Commisison facilitates enforcement.

Province of Ontario

"The Public Health Act" of Ontario contains several sections dealing with pollution. Sec. 97 reads, "The Department (of Health) shall have the general supervision of all springs, wells, ponds, lakes, streams or rivers used as a source for a public water supply or for agricultural, domestic or industrial purposes with reference to their purity, together with the waters feeding the same, and shall examine the same from time to time when the necessity for such examination arises, and inquire what, if any pollution exists and the causes thereof.

"The Department may inquire into and hear and determine any complaint made by or on behalf of a riparian proprietor entitled to the use of water, that any industrial waste or any other polluting material of any kind whatsoever which either by itself or in connection with other matter may corrupt or impair the quality of the water or may render such water unfit for accustomed or ordinary use has been placed in, or discharged into such water, or placed or deposited upon the ice thereof, or placed or suffered to remain upon the bank or shore thereof."

Sec. 98 of this same Act prohibits the discharge of pollution and reads as follows: "No garbage, excreta, manure, vegetable or animal matter or filth shall be discharged into or be deposited in any of the lakes, rivers, streams or other waters in

Ontario or on the shores or banks thereof, and no industrial or other wastes, dangerous or liable to become dangerous to health or to become a nuisance, or to impair the safety, palatability or potability of the water supply of any municipality or riparian owner, shall be discharged into or be deposited in any of the lakes, rivers, streams, or other waters of Ontario, or on the shores or banks thereof.

"The owners and officers of boats and other vessels plying upon any such lake, river, stream or other water shall so dispose of the garbage, excreta, manure, vegetable or animal matter or filth upon such boats or vessels as not to create a nuisance or enter or pollute such lake, river, stream or other water."

Section 100 of "The Public Health Act" prohibits pollution of public water supplies. "No sewage, drainage, domestic, commercial or factory refuse, excremental or other polluting matter of any kind whatsoever which either by itself or in connection with other matter corrupts, pollutes or impairs or may corrupt, pollute or impair the quality of the water of any source of public water supply for domestic use in any municipality, or which renders or may render such water injurious to health shall be placed in, deposited on, or discharged into the waters, or placed or deposited upon the ice of any such source of water supply, or be placed, deposited or discharged, or suffered to remain in, or upon the bank or shore of any such source of water supply, or in, or upon any lands adjacent to any such source, nor shall any person bathe or swim in the water of any such source of water supply."

The approval of the Department of Health is required before work is undertaken on any public water works or sewerage system. Similarly, the Department has authority to require that any water works or sewerage system be constructed, extended, enlarged or altered.

An amendment to "The Rivers and Lakes Improvement Act" passed in 1949 reads as follows: "Section 30 of The Lakes and Rivers Improvement Act is repealed and the following substituted therefor:

"In this section 'mill' means a plant or works in which logs or woodbolts are processed and includes a saw mill, a pulp mill, and a pulp and paper mill.

"Where in an action or proceeding a person claims, and but for this section would be entitled to, an injunction against the owner or occupier of a mill for an injury or damage, direct or consequential, sustained by such person, or for any interference directly or indirectly with any rights of such person as riparian proprietor or otherwise, by reason or in consequence of the throwing, depositing, or discharging, or permitting the throwing, depositing or discharging of any refuse, sawdust, chemical substance or matter from the mill or from it and other mills into any lake or river, or by reason or in consequence of any odour arising from any such refuse, sawdust, chemical substance or matter so thrown, deposited or discharged or so permitted to be thrown, deposited or discharged, the court or judge may:—

(a) refuse to grant an injunction if it is proved that having regard to all the circumstances and taking into consideration the importance of the operation of the mill to the locality in which it operates and the benefit and advantage, direct and consequential, which the operation of the mill confers on that locality and on the inhabitants of the locality, and weighing the same against the private injury, damage or interference complained of, it is on the whole proper and expedient not to grant the injunction; or

(b) grant an injunction to take effect after such lapse of time or upon such terms and conditions or subject to such limitations or restrictions as may be deemed proper; or

(c) in lieu of granting an injunction, direct that the owner or occupant of the mill take such measures or perform such acts to prevent, avoid, lessen or diminish the injury, damage or interference complained of as may be deemed proper.

"Nothing in subsection 2 shall affect any right of the person claiming the injunction to damages against the owner or occupier of the mill for any such injury, damage or interference.

"Where damage from the same cause continues the person entitled to the damages may apply from time to time in the same action or proceeding for the assessment of subsequent damages or for any other relief to which by subsequent events he may from time to time become entitled.

"This section shall apply whether the injury, damage or interference is or is not a continuing one, and whether the person claiming the injunction in the action or proceeding is a plaintiff or is a defendant proceeding by way of counterclaim.

"Section 30 of 'The Lakes and Rivers Improvement Act,' as re-enacted by subsection 1 of this section, shall apply to every action or proceeding in which an injunction is claimed in respect of any of the matters mentioned in such section, including every action or proceeding in which an injunction has been granted and in which any appeal is pending."

Municipal Regulations

Municipalities are authorized to enact regulations or by-laws dealing with such local matters as control of pollution, restrictions on the use of sewers, setting rates for sewer service rates, and financing.

Chapter VI

WATER-BORNE DISEASES

The incidence of water-borne diseases has been utilized for many years to evaluate the effects of sewage pollution. Statistical data on these diseases are available for long periods. For purposes of this investigation these records have been confined to typhoid fever and other enteric diseases. These diseases have been conspicuous ever since public water supplies were developed, either in the form of actual outbreaks or as potential menaces.

Epidemiological Studies

Consideration has been given to the findings of the 1913 survey, as recorded in the Progress Report of the International Joint Commission, dated January 16, 1914. At that time two special reports were presented as appendices: "Sanitary Conditions in Cities and Towns Situated on the United States Side of the Boundary Waters with Special Reference to Typhoid Fever" and "Typhoid Fever Statistics and Some Sanitary Facts Affecting its Undue Prevalence in Ontario." Typhoid fever death rates were given for various municipalities along the boundary waters. The excessive prevalence of this disease on the United States side, especially in the winter and spring months, was attributed in greatest measure to the sewage pollution of the interstate and international waters used as a source of public water supply. It was also stated that in Ontario the typhoid rates were excessive in most parts of the province, and they were highest of all in those municipalities situated on the international waters. Their studies led the investigating authorities to conclude that high typhoid rates in cities and towns were closely related to sewage pollution of water supplies.

Comparable statistics for 1947, presented in table 11, show that typhoid fever has been virtually eliminated. In neither Michigan nor Ontario has there been a single typhoid fever outbreak attributable to a public water supply in the past 15 years.

The 1913 report mentions the existence of "Winter Cholera," a local name for an enteric disease prevalent in the area and which might be termed enteritis or diarrhea. Since this disease was never reportable, and at present only diarrhea and enteritis in children under 2 years of age is reportable, there are but few epidemiological facts or little information for this disease which could be studied in connection with this survey. An epidemic of gastro-enteritis occurred in Detroit in 1926 when 45,000 persons were affected, and a total population of 1,300,000 was exposed. This incident was reported to have been traced to sewage pollution of the water supply, despite the fact that filtration and chlorination were in use.

The previous report contains no information on diseases resulting from swimming in polluted waters. In recent years an occasional case of typhoid has been attributed to swimming in this area. This is supported by evidence presented by

TABLE 11—TYPHOID FEVER MORTALITY

Total Deaths and Death Rates Per 100,000 Population

Municipality	1913		1920		1930		1940		1947	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
State of Michigan	538	17.5	300	8.2	89	1.8	11	0.2	5	0.08
Port Huron, Mich	5	26.6	4	15.4	2	6.4	0	0	0	0
St. Clair, Mich	0	0	1	31.2	0	0	0	0	0	0
Marine City, Mich	4	106.4	1	26.8	0	0	0	0	0	0
Detorit, Mich	153	29.4	61	6.1	16	1.0	5	0.3	0	0
Wyandotte, Mich	7	70.3	17	122.7	0	0	0	0	0	0
Monroe, Mich	1	12.1	1	8.6	0	0	0	0	0	0
Province of Ontario	446	16.7	203	7.0	76	2.3	26	0.7	6	0.1
Sarnia, Ont	5	43.5	3	20.5	0	0	0	0	0	0
Wallaceburg, Ont	......	......	......	......	0	0	0	0	0	0
Chatham, Ont	7	56.5	3	19.2	1	6.1	0	0	0	0
Windsor, Ont	2	9.3	3	8.2	3	4.3	0	0	0	0
Amherstburg, Ont	......	......	......	......	0	0	0	0	0	0

the city of Detroit in the hearings before the International Joint Commission in 1948. About 3 years previous to this, a few cases of typhoid fever gave histories of swimming at the beaches adjacent to the Nine Mile Drain outlet into Lake St. Clair. There was strong circumstantial evidence that this was the source of infection.

No information is available on the number of cases of other diseases which might result from swimming because these are not reportable. It is believed, however, that infections of this kind are not uncommon.

Effect of Water Purification

The fact that typhoid fever from public water supplies has virtually disappeared must not be construed to mean that pollution has diminished. On the contrary, pollution of these waters has been steadily increasing, but water purification processes have made notable advances and, in general, have been able to cope with the problem of producing a safe water, even under adverse circumstances.

In the 1913 investigation epidemiological data on typhoid fever from public water supplies was given major consideration. The prevalence of this disease and the bacterial quality of the water were the main criteria for determining the intensity and effect of the pollution. Now, water-borne disease no longer plays as prominent a role insofar as public water supplies are concerned, because of the protection afforded by treatment processes. Careful consideration must now be given to the growing problem of producing potable water of attractive physical characteristics in an economical manner. Other yardsticks must therefore be utilized to supplement the bacteriological examinations in appraising the significance of pollution. Such measures were selected and are discussed later in the report.

Chapter VII

SOURCES AND CHARACTER OF POLLUTION

Pollution in these boundary waters originates principally from domestic and industrial sources located along the shores. These wastes are of primary importance since their effects are imposed directly on the boundary waters, but sources of pollution on tributary streams were also studied to ascertain if the effects of those wastes were transmitted to the boundary waters.

Data on domestic wastes were secured from local, state, and provincial authorities. Where sewage treatment plants were operating the records of these were used. In others, the information was obtained from water consumption, population figures, and engineering reports.

A total of 62 industrial plants was studied, 45 being in the United States and 17 in Canada. Complete sampling and gaging studies were made at the larger industries and at those where little information was available. Where sufficient information on the quantity and character of the wastes was available from state and provincial authorities, or from some other reliable source, it

TABLE 12—PRINCIPAL SOURCES OF DOMESTIC WASTES—LAKE HURON-LAKE ERIE SECTION

Municipality	Receiving Stream or Lake	Population		Degree of Sewage Treatment
		Total (Est. 1948)	Served by Sewers	
Port Huron, Mich	St. Clair River	38,900	31,100	None
Marysville, Mich	"	2,400	1,800	"
St. Clair, Mich	"	4,100	3,700	"
Marine City, Mich	"	4,300	3,700	"
Algonac, Mich	"	2,200	1,600	"
Sarnia, Ont	"	23,000	22,000	"
Sarnia Township, Ont	"	8,600	1,000	"
New Baltimore, Mich	Lake St. Clair	2,000	800	"
Mt. Clemens, Mich	Clinton River	22,300	16,700	"
St. Clair Shores, Mich	Lake St. Clair	16,300	4,100	Primary
Warren Township, Mich	"	27,700	16,600	"
Grosse Pte. Shores, Mich	"	1,000	300	"
Grosse Pte. Farms, Mich	"	8,100	8,100	"
Grosse Pte. Woods, Mich	"	3,900	3,100	"
Groose Pte., Mich	"	7,500	7,500	"
Grosse Pte. Park, Mich	"	13,800	13,800	"
East Detroit, Mich	"	15,300	13,800	"
Centerline, Mich	"	6,500	4,800	"
Roseville, Mich	"	14,400	8,600	"
Wallaceburg, Ont	Sydenham River	6,900	1,700	None
Chatham, Ont	Thames River	21,000	18,000	"
Tecumseh, Ont	Lake St. Clair	3,300	500	"
Detroit, Mich	Detroit River	1,888,200	1,878,700	Primary
Hamtramck, Mich	"	57,700	57,700	"
Highland Park, Mich	"	57,100	57,100	"
Dearborn, Mich	Rouge River	79,400	71,400	"
Melvindale, Mich	"	6,100	6,000	None
River Rouge, Mich	Detroit River	20,300	20,300	Primary
Ecorse, Mich	"	16,200	16,000	"
Allen Park, Mich	"	4,500	4,400	"
Lincoln Park, Mich	"	19,300	19,100	"
Wyandotte, Mich	"	37,700	37,400	"
Riverview, Mich	"	1,200	1,200	"
Trenton, Mich	"	6,500	6,400	"
Riverside, Ont	"	6,800	5,000	Secondary
Windsor, Ont	"	119,600	115,000	None
Sandwich East, Ont	"	13,000	1,500	"
Sandwich West, Ont	"	7,400	1,200	"
Amherstburg, Ont	"	3,300	1,800	"

was used. In all cases data and findings on the wastes were reviewed and agreed to by the industries concerned.

Vessels engaged in freight and passenger traffic contribute pollution because of their sewage and refuse disposal. Information on the number of passengers and crew carried served as the basis for determining the pollution load. Pleasure craft in large numbers also ply these waters, particularly in the Detroit River area, and contribute pollution.

Domestic Wastes

All the larger municipalities are sewered, but in 17 out of a total of 39 of these the sewage is discharged untreated. In addition, there are many small communities, with waterworks systems, where sewers will ultimately be built. These constitute a potential pollution problem. Information on the main sources of domestic wastes for this section of the boundary waters is recorded in table 12. It should be noted that the figures on population do not include any equivalent for industrial wastes entering public sewers.

The municipalities served by sewage treatment plants are all located in the Lake St. Clair and Detroit River areas. All but one are in the United States. The data presented in table 12 are summarized in table 13 to show these populations by areas.

TABLE 13—SUMMARY OF SEWAGE COLLECTION AND TREATMENT BY AREAS

Area	Total Population (Est. 1948)	Populations Served		
		By Sewers Only	By Sewers and Treatment	Total
St. Clair River..	83,500	64,900	0	64,900
Lake St. Clair...	170,000	37,700	80,700	118,400
Detroit River...	2,344,300	125,500	2,174,700	2,300,200
Total.......	2,597,800	228,100	2,255,400	2,483,500

Out of a total estimated population in 1948 of 2,598,000 persons about 2,484,000 are served by sewer systems, and of these 2,255,000 are served by sewage treatment works. The Detroit plant serves 2,200,000 of this total. All these sewer systems are of the combined type, with storm and sanitary wastes carried in the same sewer. The sewerage system in Detroit is incomplete in that there are still a number of outlets discharging raw sewage directly to the river rather than to the interceptor.

The total estimated volume of municipal wastes discharged to the waters of these areas is tabulated in table 14. These totals include a variety of wastes contributed by industries located within the municipalities and connected to the public sewers. While table 13 shows a high percentage of the population being served by sewage treatment only a minor percentage is served by secondary or biological treatment.

TABLE 14—VOLUME OF MUNICIPAL WASTES

Area	Volume—Million Gallons per Day			
	United States (U. S.) Gallons)	Canada (Imp. Gallons)	Total—Both Sides	
			U. S. Gallons	Imp. Gallons
St. Clair River.....	14	4	19	16
Lake St. Clair......	5	7	13	11
Detroit River. . . .	466	13	482	401
Total......	485	24	514	428

Sewage Treatment Plants

The largest sewage treatment plant in this section is operated by the city of Detroit. It provides primary treatment, chlorination of the effluent, and incineration of the sludge. The plant receives the dry weather flow from the city itself and from 22 surrounding communities under contract agreements with the city. The Wayne County Board of Road Commissioners operates two sewage treatment plants on the boundary waters, serving nine communities. These are located at Wyandotte and Trenton and provide primary treatment with chlorination of the effluent and incineration of the sludge. The effluents discharge to the Detroit River. The city of Dearborn has two sewage treatment plants which discharge into the lower Rouge River. Both provide primary treatment without chlorination of the effluent, but with sludge incineration. In addition to Dearborn these plants serve all or part of three adjoining communities. On the Canadian side the town of Riverside has secondary treatment of the activated sludge type.

Details on these various plants are as follows:

Detroit Plant

Operated by: Board of Water Commissioners, City of Detroit.

Communities Served: Detroit, Hamtramck, Highland Park, East Detroit, Ferndale, Huntington Woods, Oak Park, Pleasant Ridge, Grosse Pointe, Grosse Pointe Park, Grosse Pointe Shores, Grosse Pointe Woods, Grosse Pointe Farms, St. Clair Shores, Roseville, Hazel Park, Berkley, Clawson, Centerline, Royal Oak, Southfield Twp., Warren Twp., Redford Twp.

Treatment: Sedimentation—chlorination of efflu-

ent–sludge conditioning, vacuum filtration, and incineration.
Design Flow: 420 M. G. D. (U. S.).
Present Flow: 350 M. G. D. (U. S.).
Design Population: 2,400.000.
Population Served: 2,200,000 (exclusive of industrial wastes).
Receiving Stream: Detroit River.

Wyandotte Plant

Operated by: Wayne County Board of Road Commissioners.
Communities Served: River Rouge, Ecorse, Wyandotte, Lincoln Park, Allen Park, Riverview, Ecorse Twp. (part), Taylor Twp. (part).
Treatment: Sedimentation–chlorination of effluent–sludge conditioning, vacuum filtration, and incineration.
Design Flow: 12.5 M. G. D. (U. S.).
Present Flow: 13 M. G. D. (U. S.).
Design Population: 100,000.
Population Served: 100,000 (exclusive of industrial wastes).
Receiving Stream: Detroit River.

Trenton Plant

Operated by: Wayne County Board of Road Commissioners.
Community Served: Trenton.
Treatment: Sedimentation–chlorination of effluent–sludge to Wyandotte Plant for conditioning, vacuum filtration, and incineration.
Design Flow: 2.0 M. G. D. (U. S.).
Present Flow: 1.0 M. G. D. (U. S.).
Design Population: 20,000.
Population Served: 6,400 (exclusive of industrial wastes).
Receiving Stream: Detroit River.

Dearborn Plants

Operated by: City of Dearborn.
Communities and Population Served:

Dearborn	71,400
Inkster	5,000
Detroit	205,000
Wayne	7,500
Miscellaneous	31,500
	320,400

East Side Plant
Treatment: Sedimentation (Imhoff Tanks)–effluent to river without chlorination–sludge to west side plant for disposal.
Design Flow: 20 M. G. D. (U. S.).
Present Flow: 30-35 M. G. D. (U. S.).
Receiving Stream: Rouge River.
West Side Plant
Treatment: Sedimentation–effluent to river without chlorination–sludge conditioning, vacuum filtration, and incineration.
Design Flow: 12 M. G. D. (U. S.).
Present Flow: 8-10 M. G. D. (U. S.).
Receiving Stream: Rouge River.

Riverside Plant

Operated by: Town of Riverside.
Community Served: Riverside.
Population Served: 5,000.
Treatment: Activated sludge–effluent discharged without chlorination–sludge drying beds.
Design Flow: 250,000 Imp. Gal. per day.
Present Flow: 350,000 Imp. Gal. per day.
Receiving Stream: Creek to Detroit River.

It will be noted that Dearborn's east side sewage treatment plant is now seriously overloaded. The plants at Wyandotte and Riverside are now somewhat overloaded. Except for Trenton, the other plants have only limited reserve capacities.

Sources of pollution exist outside the sewered communities. Among these are the smaller urban centers, groups of summer cottages and waterfront residences. In some instances sewage is discharged directly into the boundary waters. In others it first passes through septic tanks without supplemental treatment. These afford inadequate protection.

Correction of the sewage pollution problem will require not only adequate sewage treatment plants but trunk sewers and interceptors as well. Sewage collection and treatment facilities for all urban communities should be an objective for the entire area.

Combined Sewer Overflows

In addition to the dry weather sanitary flow large volumes of deleterious wastes reach the boundary waters through storm water overflows. In combined sewers only the dry weather flow, together with some multiple of this as storm water, is intercepted and carried to the treatment plant. Usually this multiple does not exceed two to three. The excess mixture of storm and sanitary flow escapes directly to the boundary waters and tributaries.

Combined sewer overflows are numerous and widely distributed along the boundary waters and tributaries. The major ones, in the Lake Huron-Lake Erie section, discharge into Red Run and the Clinton River from South Eastern Oakland County, into Lake St. Clair from the Nine Mile and Martin Drains in Southern Macomb County, into Fox and Conner Creeks from the Detroit east side district, into the Rouge River from the Detroit west side district, and into the lower Detroit River from Wayne County drains. For Detroit alone there are 72 such overflows into the

Detroit and Rouge Rivers. None of these combined sewer overflows receives any treatment, and consequently this prevents full benefit being realized from existing interceptors and treatment facilities. Intermittent pollution occurs under those conditions.

Refuse Disposal

Careless and thoughtless disposal of garbage and other kinds of refuse is an added factor in the pollution problem. These wastes add pollution, create an unsightly appearance, and present hazards to small watercraft. They originate from boats, from shore residences, and from wilful dumping by careless persons. While much refuse was formerly dumped by municipalities there is little evidence that disposal from such sources is now taking place. Other sources are difficult to control and require constant vigilance. The practice of dumping refuse in locations where it can drain into or directly enter these waters is highly objectionable, and all means should be taken to prevent it.

Industrial Wastes

Industrial wastes are the chief source of chemical pollution, as distinguished from bacterial pollution in sewage. They are much less significant from a disease standpoint. The chief objection to many of these wastes is that they contain oils, toxic substances, or taste and odor producing compounds. Other polluting effects result from the discharge of solids, acids, oxygen-consuming wastes, and materials which impart an unsightly appearance.

Pollution by industrial wastes occurs throughout the Lake Huron-Lake Erie section but is heaviest in the upper St. Clair and lower Detroit Rivers. Table 15 lists the types of industries studied.

TABLE 15—NUMBER AND TYPES OF INDUSTRIES STUDIED

Type of Industry	Number of Plants		
	United States	Canada	Total
Automotive	4	1	5
Chemical	16	3	19
Distillery	0	2	2
Gas Manufacturing	4	1	5
Metal, Miscellaneous	4	3	7
Oil	2	1	3
Paper	3	0	3
Rubber	1	1	2
Salt	2	1	3
Steel	3	1	4
Miscellaneous	6	3	9
Total	45	17	62
Coke Plants—Part of larger industries and included above	4	0	4

Information on the industrial wastes produced daily in the Lake Huron-Lake Erie section is contained in table 16. The flows shown include con-

TABLE 16—SUMMARY OF INDUSTRIAL WASTES DISCHARGED DAILY

Area	Total Flow—M.G.D.		Phenols (Pounds)	Cyanides (Pounds)	Ammonium Compounds (Pounds)	Oils, etc.		Susp. Solids (Pounds)
	U. S.	Imp.				U. S. Gal.	Imp. Gal.	
UNITED STATES SIDE								
St. Clair River	24	20	0	0	15	40	30	33,400
Lake St. Clair	5	4	1,230	0	40	0	0	0
Detroit River	1,173	977	4,890	3,690	11,010	16,240	13,520	1,669,200
Total	1,202	1,001	6,120	3,690	11,065	16,280	13,550	1,702,600
CANADIAN SIDE								
St. Clair River	133	111	220	2	0	2,450	2,040	50,300
Lake St. Clair	11	9	0	1	0	0	0	2,900
Detroit River	84	70	0	2	560	0	0	540,100
Total	228	190	220	5	560	2,450	2,040	593,300
COMBINED—UNITED STATES AND CANADA								
St. Clair River	157	131	220	2	15	2,490	2,070	83,700
Lake St. Clair	16	13	1,230	1	40	0	0	2,900
Detroit River	1,257	1,047	4,890	3,692	11,570	16,240	13,520	2,209,300
Total	1,430	1,191	6,340	3,695	11,625	18,730	15,590	2,295,900

denser and cooling waters as well as the process wastes. Where industrial wastes are discharged into tributary systems the total amount of the polluting constituents may not reach the boundary waters since natural purification tends to reduce or alter these substances. This is true particularly of organic substances such as phenols, cyanides, ammonium compounds, and oils.

Origin of Wastes

The waste constituents shown in table 16 result from a variety of industrial processes, and each plant may produce one or more of these. They are discharged at both uniform rates and in batches of varying concentrations. The latter constitute a "slug" or a "spill." The industries are listed below according to the types of wastes discharged. The general locations of their outfalls are designated by the same code letters as shown in table 1 of chapter II.

Phenolic Compounds—Phenol and phenolic equivalents are derived from by-product coke and gas plant operations, from crude oil refining, and from plants in which phenol is used as a raw material.

Phenolic compounds were found, on the United States side, in the wastes from

- The Detroit Edison Company (SR)
- Reichhold Chemicals Incorporated (Cl)
- Michigan Consolidated Gas Company (Dt and Dt. Rg)
- Semet-Solvay Division of Allied Chemical & Dye Corporation (Dt)
- Barrett Division of Allied Chemical & Dye Corporation (Dt Rg)
- Great Lakes Steel Corporation (Dt)
- Ford Motor Company (Dt Rg)
- Wyandotte Chemicals Corporation (Dt)
- Sharples Chemicals Incorporated (Dt)

and, on the Candian side, in the wastes from

- Imperial Oil Limited (SR)
- Union Gas Company, Limited (SR)

Cyanides—Cyanides come chiefly from electric plating processes, by-product coke ovens, and from tar processing plants. They were found, on the United States side, in the wastes from

- Semet-Solvay Division of Allied Chemical & Dye Corporation (Dt)
- Barrett Division of Allied Chemical & Dye Corporation (Dt Rg)
- Ford Motor Company (Dt Rg)

and, on the Canadian side, from

- Mueller Limited (SR)
- Sydenham Trading Company (Sy)
- Wallaceburg Brass, Limited (Sy)
- Canadian Steel Corporation, Limited (Dt)

Ammonium Compounds—Ammonium compounds are found in the wastes of by-product coke ovens, chemical plants, gas plants, and tar processing plants. They were present, on the United States side, in the wastes from

- Reichhold Chemicals Incorporated (Cl)
- Michigan Consolidated Gas Company (Dt and Dt Rg)
- Solvay Process Division of Allied Chemical & Dye Corporation (Dt)
- Semet-Solvey Division of Allied Chemical & Dye Corporation (Dt)
- Barrett Division of Allied Chemical & Dye Corporation (Dt Rg)
- Ford Motor Company (Dt Rg)
- Wyandotte Chemicals Corporation (Dt)
- Sharples Chemicals Incorporated (Dt)

and, on the Canadian side, from

- Brunner Mond Canada, Limited (Dt)

Oils and Greases—Oils and greases were found, on the United States side, in the wastes from

- Pressed Metals of America, Incorporated (SR)
- U. S. Rubber Company (Dt)
- Michigan Consolidated Gas Company (Dt and Dt Rg)
- American Brass Company (Dt)
- Revere Copper and Brass Company (Dt)
- Semet-Solvay Division of Allied Chemical & Dye Corporation (Dt)
- Barrett Division of Allied Chemical & Dye Corporation (Dt Rg)
- Great Lakes Steel Corporation (Dt)
- Ford Motor Company (Dt Rg)
- Darling and Company (Dt & Rg)
- Fuel Oil Corporation (Dt)
- Murray Corporation of America (Dt)
- Wyandotte Chemicals Corporation (Dt)
- Warner G. Smith Company (Dt)
- Firestone Rubber and Metal Products Company (Dt)
- Sharples Chemicals Incorporated (Dt)
- Socony-Vacuum Oil Company (Dt)

and, on the Canadian side, from

- Imperial Oil Limited (SR)
- Union Gas Company Limited (SR)
- Polymer Corporation (SR)
- Darling and Company, Limited (Th)
- Ford Motor Company of Canada. Limited (Dt)

Suspended Solids—Suspended solids were found, on the United States side, to be contributed chiefly from

- Dunn Paper Company (SR)
- Port Huron Sulphite and Paper Company (SR Bk)
- Morton Salt Company (SR)
- Diamond Crystal-Colonial Salt Division (SR and SR Pn)
- U. S. Rubber Company (Dt)
- Michigan Consolidated Gas Company (Dt and Dt Rg)

Solvay Process Division of Allied Chemical & Dye Corporation (Dt)
Semet-Solvay Division of Allied Chemical & Dye Corporation (Dt)
Peerless Portland Cement Company (Dt Rg)
Detroit Sulphite Pulp and Paper Company (Dt Rg)
Great Lakes Steel Corporation (Dt)
Darling and Company (Dt Rg)
Ford Motor Company (Dt Rg)
Wyandotte Chemicals Corporation (Dt)
Pennsylvania Salt Manufacturing Company (Dt)
Werner G. Smith Company (Dt)
Sharples Chemicals Incorporated (Dt)

and, on the Canadian side, from

Dominion Salt Company (SR)
Imperial Oil Limited (SR)
Polymer Corporation (SR)
Canada and Dominion Sugar Company Limited (Sy and Th)
Darling and Company Limited (Th)
Ford Motor Company of Canada Limited (Dt)
Hiram Walker & Sons Limited (Dt)
Canadian Industries Limited (Dt)
Brunner Mond Canada Limited (Dt)
Calvert Distillers (Canada) Limited (Dt)

Biochemical Oxygen Demand—Biochemical Oxygen Demand comes from organic materials of all kinds. Substantial amounts were found, on the United States side, in the wastes from

Port Huron Sulphite and Paper Company (SR Bk)
Parke, Davis & Company (Cl and Dt)
Reichhold Chemicals Incorporated (Cl)
Franklin County Sugar Company (Cl)
U. S. Rubber Company (Dt)
Detroit Sulphite Pulp and Paper Company (Dt Rg)
Solvay Process Division of Allied Chemical & Dye Corporation (Dt)
Semet-Solvay Division of Allied Chemical & Dye Corporation (Dt)
Barrett Division of Allied Chemical & Dye Corporation (Dt Rg)
Darling and Company (Dt Rg)
Michigan Consolidated Gas Company (Dt and Dt Rg)
Ford Motor Company (Dt Rg)
Werner G. Smith Company (Dt)
Sharples Chemicals Incorporated (Dt)

and, on the Canadian side, from

Imperial Oil Limited (SR)
Polymer Corporation (SR)
H. J. Heinz Company of Canada Limited (Sy)
Canada and Dominion Sugar Company Limited (Sy and Th)
Darling and Company Limited (Th)
Ford Motor Company of Canada Limited (Dt)
Hiram Walker & Sons Limited (Dt)
Brunner Mond Canada Limited (Dt)
Calvert Distillers (Canada) Limited (Dt)

The biochemical oxygen demand (B.O.D.) test of a waste is a measurement of the strength or concentration of its oxidizable organic matter. The "Population Equivalent" values provides a basis on which industrial wastes may be compared with domestic sewage insofar as oxygen consuming qualities are concerned. The coefficient of 0.168 pound of 5-day, 20°C., B.O.D. per capita per day is used for converting the B.O.D. value to a population equivalent figure. The B.O.D. of the industrial wastes and their corresponding equivalents are listed in table 17. These figures do not necessarily imply an equivalent bacterial pollution load.

Miscellaneous—Miscellaneous polluting substances, as indicated, were found, on the United States side, in the wastes from

Port Huron Sulphite & Paper Company—acid—(SR Bk)
American Brass Company—acid and copper—(Dt)
Revere Copper & Brass Company—acid and copper—(Dt)
Great Lakes Steel Corporation—acid and iron—(Dt)
General Chemical Division of Allied Chemical & Dye Corporation—acid—(Dt)
Murray Corporation of America—acid and iron—(Dt)

TABLE 17—POPULATION EQUIVALENT OF INDUSTRIAL WASTE DISCHARGES

Area	B.O.D.—Pounds Daily			Population Equivalents—Persons		
	United States	Canada	Total	United States	Canada	Total
St. Clair River	58,500	21,500	80,000	348,000	128,000	476,000
Lake St. Clair	27,500	30,600	58,100	164,000	182,000	346,000
Detroit River	153,900	62,500	216,400	916,000	372,000	1,288,000
Total	239,900	114,600	354,500	1,428,000	682,000	2,110,000

E. I. Dupont de Nemours & Company, Incorporated–acid–(Dt)
Halowax Products Division of Union Carbide and Carbon Corporation–acid–(Dt)
Firestone Rubber and Metal Products Company–acid and iron–(Dt)
Monsanto Chemical Company–phosphorus–(Dt)
American Agricultural Chemicals Company–acid–(Dt Rg)
Detroit Michigan Stove Company–sanitary sewage–(Dt)
Great Lakes Engineering Works–sanitary sewage–(Dt)
Ford Motor Company–acid and iron–(Dt Rg)

and, on the Canadian side, from

Mueller Limited–acid and chrome–(SR)
Polymer Corporation–acid–(SR)
Ford Motor Company of Canada Limited–acid–(Dt)
Canadian Industries Limited–acid–(Dt)
Canadian Steel Corporation, Limited–acid and iron–(Dt)

Taste Examination of Industrial Wastes

Certain industrial wastes are known to cause objectionable tastes and odors in drinking waters. Many of the wastes in this section are complex in chemical structure, and insufficient information was available on their behavior when subjected to water treatment processes, particularly chlorination. Since it was believed that analytical methods alone would not give a complete measure of their taste-producing properties, it was deemed essential to undertake a special investigation of this problem.

Samples were collected from the several process wastes of the Polymer Corporation, Imperial Oil Limited, Union Gas Company Limited, and the Dow Chemical of Canada, Limited, all in the Sarnia, Ontario, area and from the Reichholds Chemicals Incorporated in Ferndale, Michigan. The examinations were made to determine the taste and odor producing properties of wastes containing phenols, and of other wastes containing aromatic substances.

In order that an industrial waste may affect a water supply

(1) the waste must be of sufficient volume and must possess sufficient potency of the taste and odor producing substances, either alone or when combined with other wastes, to withstand intermediate dilution.

(2) the constituents of the wastes responsible for the taste must be able to persist, continuously or periodically, through transportation from the point of discharge to the affected waterworks intake.

From this special investigation the following conclusions were reached:

(1) The wastes from all five industries involved in this special investigation possess taste-producing properties, but the reaction of each varies with dilution and chlorination.

(2) High phenol concentrations were present in specific wastes of the Reichhold Chemicals Incorporated and the Imperial Oil Limited.

(3) Chlorination tests on the various wastes for development and persistence of tastes were made, using varying dosages of chlorine. These showed that the measure of phenolic material, regardless of analytical techniques, does not necessarily reveal its ability to produce taste upon chlorination.

(4) Several wastes had their taste-producing properties enormously enhanced by chlorination. These included the phenol distillate from Reichhold Chemicals Incorporated, and the caustic lye wash (C.L.W.) draw-off and "411" agitator wastes from Imperial Oil Limited. These wastes also showed extreme variation in the taste produced as the chlorine-to-waste ratio was varied, and demonstrated that no limited examination would adequately assay the potential importance of the waste as a source of taste and odor difficulties. This is particularly exemplified by the Reichhold wastes.

(5) The cracking coil effluent water from Imperial Oil Limited, when chlorinated, showed a progressive decrease in its taste-producing characteristics with increasing dosages.

(6) In the Polymer Corporation isobutylene (I.P.S.) acid waste the taste intensity was substantially unchanged by partial or complete chlorination.

(7) Polymer Corporation light end (L.E.R.) caustic and Canadian Synthetic Rubber (C.S.R.) caustic wastes had taste and odor producing properties which not only were quickly rendered innocuous by simple chlorination, but which also could not survive simple aerobic dilution at normal pH.

(8) It was shown that the waste from the Polymer Corporation oil separator had its maximum taste in the unchlorinated control sample, and that a complete range of chlorination did not increase the taste above that shown in the control sample.

Wastes from Navigation

Studies were made to determine the amount and significance of pollution resulting from navigation on the boundary waters. The volume of water-borne commerce for the 1947 season was reported to be at an all time high for a peace time year and was therefore used as the basis for these studies. Data on vessel passages and freight and passenger traffic were compiled from the records of the U. S. Corps of Engineers.

Sanitary wastes from vessels are confined mostly to the navigation channels, and discharges occur intermittently along the entire route. Wastes are also discharged while vessels are in port. In some instances retention tanks have been provided for storage of sewage while at dock. When sewage is so stored the collection is deposited shortly after departure from the restricted area. This practice has value in protecting the harbor areas, but it introduces a mass of sewage in a limited area on the navigation routes. Other vessels following shortly thereafter may draw this contaminated water for domestic purposes.

No vessels operating in this section were found to have retention tanks, except some large passenger boats and ferries. The design of most vessels makes it impracticable to collect all wastes at one point, but this should create no special obstacle in providing storage tanks. The volume of such wastes is particularly significant from large passenger vessels, some of which have a capacity up to 2,200 passengers and 200 crew members. The U. S. Public Health Service estimates the quantity of sanitary wastes to be 30 gallons per person per 24-hour day.

Pollution contributed by vessels navigating these waters is significant in quantity. Nearly three million persons traversed these waters or parts of them in 1947. The estimated total equivalent population, for a full 24-hour period, at the height of the navigation season averaged 3,900. The estimated discharge from this population was 120,000 U. S. (100,000 Imp.) gallons of sanitary wastes for each day.

Navigation companies report that garbage and other refuse are stored in containers on board vessels and subsequently dumped overboard in open bodies of water or at shore points. This practice pollutes the water and causes complaints about the fouling of bathing beaches. While no specific data are available concerning the amount of garbage produced on vessels, the value of 0.5 pound per capita per day, accepted as an average for cities, might be applied here also. On this basis, the estimated amount of garbage per day at the peak of the navigation season would average 2,000 pounds. The maximum amounts produced during the months of July and August are approximately one and one-half times the average calculated value.

Bilge water includes seepage through the hull, leakage in water lines and from pumps and machinery, and wash-down water. It accumulates at the lowest level of the vessel and contains lubricating oils, greases, and other like wastes. This mixture is discharged intermittently by the bilge pumps, usually when the vessel is in motion. The quantity of this waste is highly variable, and it is difficult to determine the quantity of oils discharged with it. Based upon records of bilge pump operation and of oil consumption, the total quantity of oil discharged from all vessels has been conservatively estimated to be about 40 U. S. gallons per day.

Ballast water is used to effect stability of the vessels under various operating conditions. It is pumped into and discharged from tanks built in the fore and after peaks and in the bottom of the vessel. Common practice is to take ballast water from overboard while unloading and to discharge it as the cargo is received. Under certain conditions ballast water is also pumped overboard while en route to lighten the load and increase the speed. Thus, contaminated water may be taken aboard at one point and transferred into a relatively clean area elsewhere. This practice is hazardous, chiefly in that pollution may be discharged in the vicinity of water supplies and bathing beaches.

Jurisdiction regarding the discharge of pollutants from vessels into these waters is embodied in the River and Harbor Act and the Interstate Quarantine Regulations of the United States Government. The former Act prohibits the deposit of any refuse matter, including sewage and oil wastes, from vessels into navigable waters of the United States or into any water which may convey the same into navigable waters. This restriction is more specifically outlined in the Interstate Quarantine Regulations. These regulations state that vessels operating on fresh water lakes or rivers shall not discharge sewage, ballast or bilge water within such areas adjacent to domestic water intakes as are designated by the Surgeon General, Public Health Service. Local regulations in many areas prohibit the discharge of any wastes from a vessel in the vicinity of water supply intakes and bathing beaches. Such restricted areas should be adequately designated and vessel operators should exert care to insure that these requirements are strictly observed.

Wastes from Dredging

The deposition of solids in the lower Rouge River originates from soil washings on the watershed and from the large volumes of domestic and industrial wastes discharged into the river. This has made it necessary for the U. S. Corps of Engineers to develop an annual program of maintenance dredging as an aid to navigation. The average annual expenditure of Federal funds for these operations is now $75,000.

Coincident with this investigation of boundary waters pollution, attention was focused on the dumping from these operations. The city of Wyandotte, Michigan, which obtains its raw water supply from the lower Detroit River, contended in June 1947 that the dumping of dredged material in the river above Fighting Island was at least partly responsible for difficulties in water treatment. The State of Michigan also concerned itself with this matter, and on October 22, 1947, the Stream Control Commission passed a resolution protesting against this practice. A preliminary study was undertaken by the Board, and a report was later made to the Commission. It was concluded at that time that some potential hazard to downstream water supplies existed.

This led to a request by the District Engineer of the U. S. Corps of Engineers, Detroit District, to the U. S. Public Health Service for a comprehensive study on the pollutional effect of these dredging operations. Accordingly, the Public Health Service undertook a special study in cooperation with the field staff of the International Joint Commission between June 1 and September 2, 1948. The findings and recommendations were reported to the District Engineer for his information and guidance in planning future dredging operations.

The Rouge River dredgings consist of a mixture of sewage solids and industrial waste solids with alluvial deposits. A typical analysis of the bottom deposits showed a high content of organic matter, iron oxide, oil, and coliform bacteria. The material was dark in color and had an offensive odor. When dumped, it released oil to the surface of the water.

These dredging operations are conducted each year for a period of approximately 50 days. The volume of material removed approximates one-half million cubic yards a year. This material contained an average daily quantity of 11.4 tons of iron (Fe), 17,400 (U. S.) gallons of oil, 2,710 pounds of sulphides, 325 tons of volatile solids, and a B.O.D. population equivalent of 373,000. These operations involve the transfer of a heavy mass of pollution from a tributary to the boundary waters.

Chapter VIII

POLLUTION EFFECTS ON BOUNDARY WATER QUALITY

The effects of pollution have been measured by bacteriological, chemical, and physical examinations. These analytical tests were supplemented by relevant data on municipal water supplies, bathing beaches, sewage effluents, combined sewer overflows, and industrial wastes. All this information has shown the extent and intensity of pollution in both the boundary waters and tributaries, the changes which take place in the zones between the sources of pollution, and the suitability of these waters for the various uses discussed previously.

Throughout the investigation, a total of 8,101 surface water samples were taken for bacteriological examinations and 10,784 for chemical tests. Analyses were made in the field laboratories at Sarnia, Windsor, and Detroit.

Explanation of Laboratory Tests

The analytical determinations used in the survey are listed below. An explanation of each is given as an aid in interpreting the significance of the tests.

Bacteriological Examinations

Bacterial examinations were limited to the confirmed test for the coliform group of bacteria. These bacteria are normal inhabitants of the intestines of warm-blooded animals and are discharged in large numbers in human feces. This test is the most delicate and specific means of approximating the density of a group of bacteria which are always present in large numbers in sewage and are, in general, relatively few in number in other stream pollutants. The results are reported as "most probable number" (M.P.N.) per 100 ml. This is commonly known as the "M.P.N. Index."

Lake Huron water, not subject to direct contamination, is relatively free of coliform bacteria, less than 5 M.P.N. per 100 ml. Raw sewage may contain about 25 million M.P.N. per 100 ml.

Chlorides

All fresh waters contain chlorides, the normal amount varying in different regions. An increase above normal is an indication of contamination from outside sources. Chlorides in water may be derived from both sewage and industrial wastes. The normal content of Lake Huron water is about 7 p.p.m. Chlorides increase the soap consuming power of water and adversely affect boiler feed water. They are not removed by the usual water purification processes.

Phenolic Compounds

Phenols and phenolic equivalents were measured by the Gibbs Method with modifications. Phenols react with chlorine to produce intensely aromatic compounds. These compounds, even when highly diluted, may give a taste and odor to the water which is variously described as medicinal, chemical, or iodoform. They taint fish and are toxic to fish depending on their concentration. Normal water contains no phenolic compounds.

Ammonium Compounds

Ammonium compounds include free ammonia and ammonium salts, but they do not include albuminoid ammonia or organic nitrogen. The ammonium ion tends to combine with chlorine to form chloramines in public water supplies and thereby increases the chlorine demand. Erratic chlorine demand constitutes a public health hazard. Ammonium compounds are also toxic to fish. Lake Huron samples showed only trace quantities. Any substantial increase may be attributed to sewage and industrial wastes of the organic type.

Chlorine Demand

The test for chlorine demand is an indicator of the amount of organic matter present. It increases with addition of sewage and other organic pollutants. The difficulty and cost of water chlorination are increased where there is a high chlorine demand.

Temperature

The temperature of water influences the solubility of oxygen and the rate of oxidation and purification.

Dissolved Oxygen

The amount of dissolved oxygen contained in unpolluted water fluctuates with the temperature. A deficiency of oxygen is replaced by solution of oxygen from the atmosphere. There is a saturation value for each temperature. At 18°C this is 9.54 p.p.m. of dissolved oxygen. Values below the saturation level indicate the presence of polluting organic substances which are absorbing oxygen from the water. The extent of this deficiency is one index of the degree of organic pollution. Substantial reduction in dissolved oxygen causes suffocation of fish.

Biochemical Oxygen Demand (B.O.D.)

The biochemical oxygen demand test indicates the amount of oxygen required for stabilization of the decomposable organic matter. The time and temperature used are 5 days and 20°C, respectively. The figure for Lake Huron water, unaffected by pollution, is less than 1 p.p.m. In contrast, raw sewage has a B.O.D. of about 200 p.p.m.

Turbidity

This test is a measure of the appearance of the water as affected by suspended material, such as silt and finely divided organic matter.

Solids

The analyses for solids include total and suspended as well as their volatile portions. The former measures the solids in solution and in suspension. The total volatile solids indicate the amount of organic matter. Both sewage and industrial wastes are significant sources of solids. Domestic sewage carries 0.2 pound of suspended solids per capita per day. Solids in industrial wastes vary with the type of industry.

The effects of suspended solids in water are reflected in difficulties associated with water purification, deposition in streams, interference with navigation, and injury to the habitat of fish.

Hydrogen Ion Concentration (pH)

The pH value of water indicates its relative acidity or alkalinity. It is a measure of intensity rather than of quantity. A pH of 7.0 is the neutral point. Higher values are in the alkaline range, and lower in the acid range. The pH of these waters is about 8. Any appreciable departure from this indicates the influence of acid or alkaline wastes.

Alkalinity

Alkalinity represents the concentration of carbonates, bicarbonates, hydroxides, and occasionally borates, silicates, and phosphates. Calcium and magnesium are the two metals which account for most of the alkalinity. Industrial waste discharges high in alkalinity will affect the hardness of the water. Hardness is an economic factor in the use of water supplies, either for domestic or industrial purposes.

Oils and Ether-Soluble Materials

These results include oils and all other ether-soluble materials such as tarry substances and greases. The presence of these pollutants renders water difficult and sometimes impractical to treat, either for industrial or domestic use. Oils make the beaches unsightly and the waters unfit for bathing. They coat water craft and are a hazard to wild fowl.

Tastes and Odors

Determinations of taste and odor quality and intensity indicate the degree of consumer acceptance of a water supply. They aid in the search for substances responsible for tastes and odors whether due to waste discharges or to organic material naturally present in the stream. Results for odors are expressed as threshold odor numbers, these increasing with the increase in dilution required to cause disappearance of the odor. Tastes are determined in a like manner, using dilutions of chlorinated samples until the taste is barely perceptible. It is expressed as the dilution needed. Both taste and odor are described by quality or characteristics as well as intensity.

Cyanides

Cyanides are probably the most toxic substances in industrial wastes. Very low concentrations are fatal to fish. Cyanides are not natural components of surface waters.

Analytical Results of the 1913 Investigation

Reference to the investigation of these waters in 1913 reveals that the nature, character and extent of the pollution found at that time differed materially from those in the 1946-1948 survey. Pollution, in the earlier investigation, came almost entirely from sanitary sewage and from vessels.

It is interesting to note in the "Report of the Consulting Sanitary Engineer upon Remedial Measures" that "none of the industrial processes are likely to result in the discharge of waste products in sufficient quantity to seriously affect the condition of the river water. * * * It seems quite likely that this subject of industrial wastes may soon become sufficiently pressing to require detailed investigation and possibly some sort of regulation." The automotive industry, which has been responsible for the major industrial growth in this area during the period 1913 to 1946, was still in its infancy. Many of the chemical and other industries existing today were either not yet established or were operating on a much smaller scale.

The findings in the earlier investigation were based entirely on B. coli examinations. The results were expressed in terms of the "Phelps Index," as the approximate number of B. coli in 100 c.c. of the sample when calculated from the results of single tube dilution tests. The "coliform group" as recorded in this report may be considered to correspond to the "B. coli group" as used formerly. Laboratory procedures have been refined in the intervening years in an effort to obtain greater precision in the estimation of the number of coliform organisms. While comparisons in results of the two investigations can be approximate only, it may be assumed that the M.P.N. figures used in the present investigation are 2.4 times greater than numbers which would be given by the "Phelps Index."

In the "Final Report of the International Joint Commission" conditions in the Lake Huron-Lake Erie section in 1913 were summarized as follows:

> "The examination showed that the waters of Lake Huron at the head of the river would be practically free from *B. coli* were it not for the pollution from vessel sewage. Samples taken about 10 miles up the lake showed absence of *B. coli* even in 100 c.c., while the water at the lower end, where vessel pollution is concentrated, showed an average of 9 *B. coli* per 100 c.c. Below the towns of Port Huron and Sarnia the waters of the St. Clair River for a stretch of about 34 miles are quite unfit for drinking purposes unless extensively treated, the *B. coli* content found in the river water exceeding 200 per 100 c.c. The pollution below these towns is due to the combined effects of the discharge of untreated sewage from vessels and the towns along the shores. Any tendency toward self-purification of the river by natural agencies is counterbalanced by the sewage and drainage from the small villages and residences along its course.
>
> "Lake St. Clair, which receives the discharge of the river, showed less evidence of pollution. Natural agencies promote in the lake a purification not found in the river.
>
> • • • • •
>
> "The extensive pollution of the Detroit River is perhaps better indicated by saying that at its head the *B. coli* count is approximately 5 per 100 c.c., and in the lower portions just below Amherstburg it reaches the enormous figure of 10,592 *B. coli* per 100 c.c.
>
> "The pollution in the Detroit River is occasioned by the discharge of raw sewage from its riparian communities, notably the city of Detroit ,and by the sewage from vessels.
>
> "The investigations * * * show that while the waters of the western end of Lake Erie are extensively polluted by the flow of the Detroit River, this pollution does not extend past the islands which separate this end from the remainder of the lake.
>
> "Lake Erie, outside of this polluted area and the polluted areas at the mouths of its tributaries and its littoral waters, affords a remarkable instance of self-purification. The purity of the main body of the lake was amply established by examination of its water at several widely separated stations."

Analytical Results of the 1946-1948 Investigation

In the present investigation the analytical results show that pollution is due mainly to domestic and industrial wastes. Sampling covered the area extending from the southern end of Lake Huron to the western end of Lake Erie. Tables 18 to 22, inclusive, present summaries of the results of bacterial, chemical, and physical analyses of samples taken during the 1946-1948 survey. The tables show maximum and minimum results, averages for chemical and physical tests, and medians for bacterial results. The median is the value equalled or exceeded by exactly half of the values in the given list.

Lake Huron

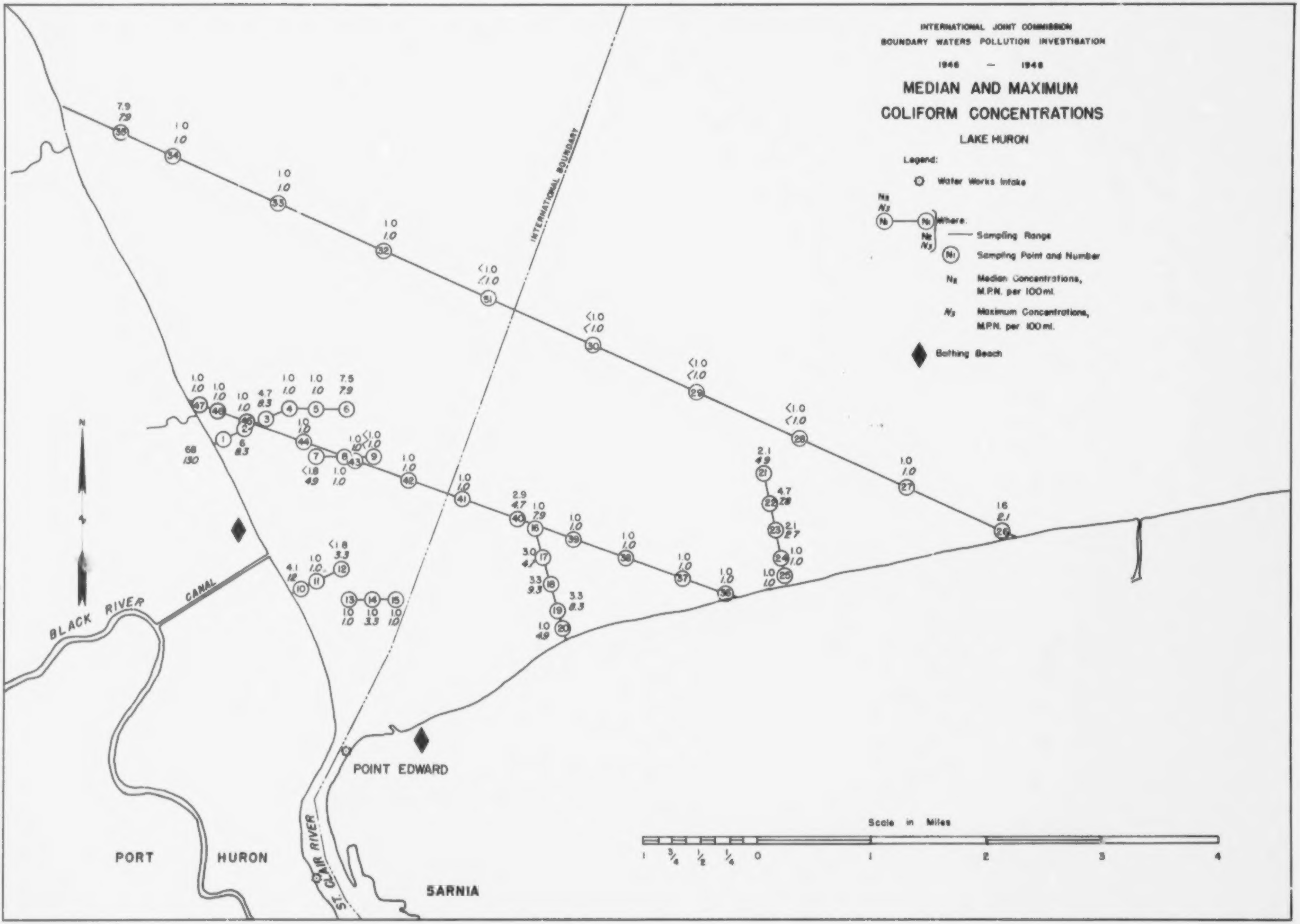
The analytical summary for samples taken at the southern end of Lake Huron is presented in table 18 (see pages 71 to 76). The coliform results are plotted in figure 3. The water is of good sanitary quality and relatively free from domestic and industrial pollution. Median coliform M.P.N. values were generally in the range of 5 or less per 100 ml., with a maximum value of 130. The quality of this water remains the same as in 1913. These results are not uncommon for clean surface waters.

Chemical and physical tests support the bacteriological findings. Dissolved oxygen values ranged between 9 and 11 p.p.m., while the B.O.D. reached a maximum of 3.2, with average values of 0.5 to 1.5 p.p.m. Phenols attained a maximum of 4 p.p.b., with most of the averages showing only trace quantities. Turbidity results were also low, the maximum being 10 p.p.m., and the averages varying between 2 and 4 p.p.m. Oils were observed only occasionally.

St. Clair River

The summary of analytical results for the St. Clair River is given in table 19 (see pages 77 to 89). Figure 4 (following page 76) shows the median coliform results and figure 5 the average phenol results. These two analyses are the most significant for these waters. Oils are also a problem here. They were observed frequently in quantity but are not measurable by river sampling.

The water entering the St. Clair River from Lake Huron is of good sanitary quality. This good quality is continued, as indicated by the low coliform results, in the middle third of the stream from Lake Huron to the communities of St. Clair and Moore, a distance of about 11 miles. The high coliform counts show heavily polluted zones near the respective shores of this upper section, reflecting the untreated sewage discharged from Port Huron, Marysville, and Sarnia. This bacterial pollution is higher on the United States side because of a greater concentration of population than on the Canadian side. The median M.P.N. values near



INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 — 1948
MEDIAN AND MAXIMUM
COLIFORM CONCENTRATIONS
LAKE HURON

Legend:
Water Works Intake
Where:
Sampling Range
Sampling Point and Number
Median Concentrations, M.P.N. per 100 ml.
Maximum Concentrations, M.P.N. per 100 ml.
Bathing Beach
Scale in Miles
1 3/4 1/2 1/4 0 1 2 3 4
INTERNATIONAL BOUNDARY
POINT EDWARD
SARNIA
PORT HURON
ST. CLAIR RIVER
BLACK RIVER
CANAL
N

Figure 3

71-a.

TABLE 18—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE HURON

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
	0.0			U. S.	Shore														
Off Gratiot Beach Sample Point No. 1	0.1	Median	68																
		Average		6.6	0.7		0.10		10.6	1.5	7.0							95	45
		Maximum	130	7.1	3		0.35		11.9	2.4	8.0							118	62
		Minimum	<1.8	6.2	0		0.10		10.0	0.80	6.0							72	28
		No. of Samples	4	2	4		3		3	4	2							2	2
Range continued Sample Point No. 2	0.25	Median	6																
		Average		6.9	0.5		0.10		10.4	2.0	7							81	55
		Maximum	8.3	7.1	2		0.10		10.6	3.2	10							112	66
		Minimum	<1.8	6.6	0		0.10		10.2	1.2	4							50	44
		No. of Samples	4	2	4		3		3	4	2							2	2
Range continued Sample Point No. 3	0.5	Median	4.7																
		Average		6.9	0.75		0.13		10.2	1.4	6							87	53
		Maximum	8.3	7.1	3		0.20		10.4	2.2	7							114	62
		Minimum	1.0	6.6	0		0.05		10.0	0.6	5							60	44
		No. of Samples	4	2	4		3		3	4	2							2	2
Range continued Sample Point No. 4	0.75	Median	1.0																
		Average		7.3	0		0.08		10.6	1.1	3							94	57
		Maximum	1.0	7.5	0		0.15		11.5	3.0	4							106	74
		Minimum	<1.0	7.1	0		0.05		10.2	0	2							82	40
		No. of Samples	4	2	4		3		3	4	2							2	2
Range continued Sample Point No. 5	1.0	Median	1.0																
		Average		7.5	0		0.10		10.0	1.4	3							79	53
		Maximum	1.0	7.9	0		0.15		10.6	2.8	3							108	72
		Minimum	<1.0	7.1	0		0.05		9.2	0	2							50	34
		No. of Samples	4	2	4		3		3	3	2							2	2
Off Gratiot Beach Sample Point No. 6	1.5	Median	1.0																
		Average		7.5	0		0.12		10.1	1.0	2							98	62
		Maximum	2.1	7.9	0		0.15		10.6	2.0	2							124	78
		Minimum	<1.0	7.1	0		0.10		9.6	0	1							72	46
		No. of Samples	4	2	4		3		3	4	2							2	2
Below Light Ship	0.0			U. S.	Shore														
Below Light Ship Sample Point No. 7	0.75	Median	<1.8																
		Average		7.1	0.5		0.08		10.1	1.4	3							92	57
		Maximum	4.9	7.1	2		0.10		10.4	2.0	4							116	72
		Minimum	<1.0	7.1	0		0.05		9.8	0.4	1							68	42
		No. of Samples	4	2	4		3		3	4	2							2	2

TABLE 18—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE HURON—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
Below Light Ship Sample Point No. 8	1.0	Median	1.0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		Average	......	7.5	0.5	......	0.10	......	10.0	1.2	3	......	......	......	......	......	......	98	64
		Maximum	1.0	7.9	2	......	0.10	......	11.1	2.6	4	......	......	......	......	......	......	122	74
		Minimum	<1.0	7.1	0	......	0.10	......	9.2	0	2	......	......	......	......	......	......	74	54
		No. of Samples	4	2	4	......	3	......	3	4	2	......	......	......	......	......	......	2	2
Edge of Channel Below Light Ship Sample Point No. 9	1.25	Median	<1.0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		Average	......	6.9	0	......	0.07	......	10.1	0.85	5	......	......	......	......	......	......	98	63
		Maximum	<1.0	7.1	0	......	0.10	......	10.5	2.2	5	......	......	......	......	......	......	122	74
		Minimum	0	6.6	0	......	0.05	......	9.6	0	4	......	......	......	......	......	......	74	52
		No. of Samples	4	2	3	......	3	......	2	4	2	......	......	......	......	......	......	2	2
	0.0			U. S.	Shore														
U. S. Shore 1.25 m. above entrance to St. Clair River Sample Point No. 10	0.1	Median	4.1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		Average	......	7.0	1	......	0.10	......	10.3	1.55	4	......	......	......	......	......	......	95	61
		Maximum	12	7.5	2	......	0.15	......	11.2	2.8	5	......	......	......	......	......	......	112	68
		Minimum	1.0	6.6	0	......	0.05	......	9.4	0	3	......	......	......	......	......	......	78	54
		No. of Samples	4	2	4	......	3	......	3	4	2	......	......	......	......	......	......	2	2
U. S. Shore 1.25 m. above entrance to St. Clair River Sample Point No. 11	0.25	Median	1.0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		Average	......	7.3	0	......	0.08	......	10.0	0.87	4	......	......	......	......	......	......	82	49
		Maximum	1.0	7.5	0	......	0.10	......	10.3	2.0	4	......	......	......	......	......	......	112	70
		Minimum	<1.0	7.1	0	......	0.05	......	9.4	0	3	......	......	......	......	......	......	52	28
		No. of Samples	4	2	4	......	3	......	3	4	2	......	......	......	......	......	......	2	2
Range continued Sample Point No. 12	0.5	Median	<1.8	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		Average	......	7.3	0.5	......	0.07	......	10.1	0.97	3	......	......	......	......	......	......	101	62
		Maximum	3.3	7.5	2	......	0.10	......	10.5	1.9	3	......	......	......	......	......	......	120	74
		Minimum	<1.0	7.1	0	......	0.05	......	9.6	0	3	......	......	......	......	......	......	82	50
		No. of Samples	4	2	4	......	3	......	3	4	2	......	......	......	......	......	......	2	2
	0.0			U. S.	Shore														
U. S. Shore 1.0 m. above entrance to St. Clair River Sample Point No. 13	0.4	Median	1.0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		Average	......	3.2	1	......	0.12	......	10.6	1.7	4	......	......	......	......	......	......	90	40
		Maximum	1.0	6.2	2	......	0.20	......	10.4	2.3	4	......	......	......	......	......	......	114	74
		Minimum	<1.0	0.2	0	......	0.05	......	9.6	1.4	3	......	......	......	......	......	......	66	6
		No. of Samples	4	2	4	......	3	......	3	4	2	......	......	......	......	......	......	2	2
Range continued Sample Point No. 14	0.6	Median	1.0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		Average	......	6.9	0.5	......	0.10	......	9.9	1.8	3	......	......	......	......	......	......	97	57
		Maximum	3.3	7.1	2	......	0.15	......	10.3	2.5	3	......	......	......	......	......	......	132	72
		Minimum	<1.0	6.6	0	......	0.05	......	9.6	0.4	3	......	......	......	......	......	......	62	42
		No. of Samples	4	2	4	......	3	......	3	3	2	......	......	......	......	......	......	2	2
Range continued Sample Point No. 15	0.8	Median	1.0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		Average	......	6.4	1.2	......	0.08	......	10.1	1.2	4	......	......	......	......	......	......	95	68

		Maximum	1.0	6.6	4		0.15		10.3	1.9	4							132	84
		Minimum	<1.0	6.2	0		0.05		9.8	1.4	3							58	52
		No. of Samples	4	2	4		3		3	4	2							2	2
Canadian Shore 2 m. east of entrance to St. Clair River Sample Point No. 16	1.0	Median	1.0																
		Average		6.7	1		0.12		10.1	1.5	7							101	56
		Maximum	7.9	7.1	2		0.20		10.4	2.0	8							124	66
		Minimum	1.0	6.2	0		0.05		10.0	0.6	6							78	46
		No. of Samples	4	2	4		3		3	4	2							2	2
Range continued Sample Point No. 17	0.75	Median	3																
		Average		7.1	0.5		0.13		9.8	1.4	10							115	78
		Maximum	4.7	7.1	2		0.20		10.1	2.1	11							132	80
		Minimum	1.0	7.1	0		0.05		9.6	1.0	9							98	76
		No. of Samples	4	2	4		3		3	4	2							2	2
Range continued Sample Point No. 18	0.5	Median	3.3																
		Average		7.1	0		0.12		9.9	1.07	10.5							115	77
		Maximum	9.3	7.1	0		0.15		10.6	1.9	12							144	88
		Minimum	0	7.1	0		0.10		9.4	0.60	9							86	66
		No. of Samples	4	2	4		3		3	4	2							2	2
Range continued Sample Point No. 19	0.25	Median	3.3																
		Average		7.1	0.66		0.13		10.1	1.3	7							98	64
		Maximum	8.3	7.1	2		0.20		10.2	1.6	9							128	84
		Minimum	1.0	7.1	0		0.05		10.0	1.0	4							68	44
		No. of Samples	3	3	3		3		2	3	2							2	2
Range continued Sample Point No. 20	0.10	Median	1.0																
		Average		6.4	0.66		0.20		9.9	1.2	15							147	81
		Maximum	49	7.1	2		0.40		10.2	1.4	26							186	98
		Minimum	1.0	5.7	0		0.05		9.6	1.0	3							108	64
		No. of Samples	3	2	3		3		2	3	2							2	2
	0.0			Canadian Shore															
Canadian Shore 4 m. east of entrance to St. Clair River Sample Point No. 21	0.1	Median	2.1																
		Average		6.8	0		0.13		9.8	1.0	10							135	72
		Maximum	49	7.1	0		0.25		10.2	1.2	17							154	84
		Minimum	1.0	6.6	0		0.05		9.4	0.8	3							116	60
		No. of Samples	3	2	3		3		2	3	2							2	2
Range continued Sample Point No. 22	0.25	Median	4.7																
		Average		6.8	0		0.13		9.9	1.1	7							117	75
		Maximum	7.8	7.1	0		0.20		10.2	1.2	7							126	82
		Minimum	1.0	6.6	0		0.10		9.6	1.0	6							108	68
		No. of Samples	3	2	3		3		2	3	2							2	2
Range continued Sample Point No. 23	0.5	Median	2.1																
		Average		6.1	0.66		0.12		9.8	1.0	8							127	73
		Maximum	27	6.2	2		0.15		10.0	1.6	8							134	80
		Minimum	<1.0	6.0	0		0.05		9.6	0.4	8							120	66
		No. of Samples	3	2	3		3		2	3	2							2	2
Range continued Sample Point No. 24	0.75	Median	1.0																
		Average		6.4	0.06		0.10		9.7	0.8	8							115	72
		Maximum	1.0	6.6	2		0.10		9.8	1.2	8							116	74
		Minimum	<1.0	6.2	0		0.10		9.6	0.2	7							114	70
		No. of Samples	3	2	3		3		2	3	2							2	2

TABLE 18—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE HURON—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N₂ ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
Range continued Sample Point No. 25	1.0	Median	1.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0.7	...	0.07	...	9.8	0.3	...	...	...	...	...	...	...	...	...
		Maximum	1.0	6.2	2	...	0.10	...	10.0	1.4	...	...	...	...	...	...	...	...	...
		Minimum	1.0	...	0	...	0.05	...	9.6	0.2	...	...	...	...	...	...	...	116	54
		No. of Samples	3	1	3	...	3	...	2	3	...	...	...	...	...	...	...	1	1
	0.0			Cana	dian	Shore													
From Canadian Shore 6 m. east of entrance to SCR to Lake View Beach U. S. Shore Sample Point No. 26	0.1	Median	1.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	0.10	...	10.5	1.4	...	...	...	...	...	...	...	...	...
		Maximum	2.1	...	0	...	...	...	10.6	2.0	...	...	...	...	...	...	...	...	...
		Minimum	1.0	...	0	...	...	...	10.4	0.8	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	2	...	...	...	...	...	...	...	...	...
Sample Point No. 27	1.0	Median	1.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	0.05	...	10.7	0.9	...	...	...	...	...	...	...	...	...
		Maximum	1.0	...	0	...	...	...	11.0	1.4	...	...	...	...	...	...	...	...	...
		Minimum	1.0	...	0	...	...	...	10.4	0.4	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	2	...	...	...	...	...	...	...	...	...
Sample Point No. 28	2.0	Median	<1.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	0.05	...	9.2	0.4	...	...	...	...	...	...	...	...	...
		Maximum	<1.0	...	0	...	...	...	9.2	...	...	...	...	...	...	...	...	...	...
		Minimum	<1.0	...	0	...	...	...	9.2	...	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	1	...	...	...	...	...	...	...	...	...
Sample Point No. 29	3.0	Median	<1.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	0.1	...	8.8	0	...	...	...	...	...	...	...	...	...
		Maximum	<1.0	...	0	...	...	...	9.2	...	...	...	...	...	...	...	...	...	...
		Minimum	<1.0	...	0	...	...	...	8.4	...	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	1	...	...	...	...	...	...	...	...	...
Sample Point No. 30	4	Median	<1.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	0.1	0	9.2	0.4	...	...	...	...	...	...	...	...	...
		Maximum	<1.0	...	0	...	...	...	9.4	0.8	...	...	...	...	...	...	...	...	...
		Minimum	<1.0	...	0	...	...	...	9.0	0	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	2	...	...	...	...	...	...	...	...	...
	475			Inter	nation	al Boun	dary												
Range Continued (Main Shipping Channel) Sample Point No. 31	5.0	Median	<1.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	0.05	...	9.3	0.5	...	...	...	...	...	...	...	...	...
		Maximum	<1.0	...	0	...	...	...	9.4	0.6	...	...	...	...	...	...	...	...	...
		Minimum	<1.0	...	0	...	...	...	9.2	0.4	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	2	...	...	...	...	...	...	...	...	...
Range continued (Main Shipping Channel) Sample Point No. 32	6.0	Median	1.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	0.05	...	9.8	0.6	...	...	...	...	...	...	...	...	...
		Maximum	1.0	...	0	...	...	...	10.2	1.0	...	...	...	...	...	...	...	...	...

		Minimum	<1.0	...	0	...	...	...	9.4	0.2	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	2	...	...	...	...	...	...	...	...	...
Range continued **Sample Point No. 33**	7.0	Median	1.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	1	...	0.05	...	10.0	0.6	...	...	...	...	...	...	...	...	...
		Maximum	1.0	...	2	...	...	...	10.4	1.0	...	...	...	...	...	...	...	...	...
		Minimum	<1.0	...	0	...	...	...	9.6	0.2	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	2	...	...	...	...	...	...	...	...	...
Sample Point No. 34	8.0	Median	1.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	0.05	...	9.7	0.7	...	...	...	...	...	...	...	...	...
		Maximum	1.0	...	0	...	...	...	9.8	1.0	...	...	...	...	...	...	...	...	...
		Minimum	<1.0	...	0	...	...	...	9.6	0.4	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	2	...	...	...	...	...	...	...	...	...
Sample Point No. 35	8.5	Median	7.9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	0.05	...	9.4	0.2	...	...	...	...	...	...	...	...	...
		Maximum	7.9	...	0	...	...	...	9.6	0.4	...	...	...	...	...	...	...	...	...
		Minimum	7.9	...	0	...	...	...	9.2	0	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	2	...	...	...	...	...	...	...	...	...
	9.0			U. S. Shore															
	0.0			Canadian Shore															
Canadian Shore 3.5 m. east of entrance SCR to Keewahdin Beach U. S. Shore Sample Point No. 36	0.10	Median	1.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	0.05	...	10.7	1.6	...	...	...	...	...	...	...	...	...
		Maximum	1.0	...	0	...	...	...	11.0	1.6	...	...	...	...	...	...	...	...	...
		Minimum	1.0	...	0	...	...	...	10.4	1.6	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	2	...	...	...	...	...	...	...	...	...
Range continued Sample Point No. 37	0.50	Median	1.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	1	...	0.10	...	10.5	1.10	...	...	...	...	...	...	...	...	...
		Maximum	1.0	...	2	...	...	...	10.8	1.4	...	...	...	...	...	...	...	...	...
		Minimum	1.0	...	0	...	...	...	10.2	0.80	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	2	...	...	...	...	...	...	...	...	...
Sample Point No. 38	1.0	Median	1.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	0.15	...	10.1	0.70	...	...	...	...	...	...	...	...	...
		Maximum	1.0	...	0	...	...	...	11.0	0.80	...	...	...	...	...	...	...	...	...
		Minimum	1.0	...	0	...	...	...	9.2	0.60	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	2	...	...	...	...	...	...	...	...	...
Sample Point No. 39	1.5	Median	1.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	0.05	...	10.7	1.0	...	...	...	...	...	...	...	...	...
		Maximum	1.0	...	0	...	...	...	11.2	1.2	...	...	...	...	...	...	...	...	...
		Minimum	1.0	...	0	...	...	...	10.2	0.80	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	2	...	...	...	...	...	...	...	...	...
Sample Point No. 40	2.0	Median	2.9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	0.10	...	10.2	0.50	...	...	...	...	...	...	...	...	...
		Maximum	4.7	...	0	...	...	...	10.4	0.60	...	...	...	...	...	...	...	...	...
		Minimum	1.0	...	0	...	...	...	10.0	0.40	...	...	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	1	...	2	2	...	...	...	...	...	...	...	...	...
	2.5			International Boundary															

TABLE 18—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE HURON—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold Raw No.	Threshold Odor, Cold Raw Nature	Threshold Odor, Cold Chlorinated No.	Threshold Odor, Cold Chlorinated Nature	Taste	Total Solids ppm Total	Total Solids ppm Volatile
From Canadian Shore 3.5 m. east of entrance to SCR to Keewahdin Beach—U. S. Shore Sample Point No. 41	2.5	Median	1.0																
		Average			0		0.10		9.6	0.30									
		Maximum	1.0		0				10.2	0.60									
		Minimum	1.0		0				9.0	0									
		No. of Samples	2		2		1		2	2									
(Main Shipping Channel)	2.5			International Boundary (Main Shipping Channel)															
Range continued Sample Point No. 42	3.0	Median	1.0																
		Average			0		0.10		9.8	0.7									
		Maximum	1.0		0				10.2	0.8									
		Minimum	1.0		0				9.4	0.6									
		No. of Samples	2		2		1		2	2									
				Main Shipping Channel															
Range continued Sample Point No. 43	3.5	Median	1.0																
		Average			0		0.10		9.6	0.10									
		Maximum	1.0		0				9.6	0.20									
		Minimum	1.0		0				9.6	0									
		No. of Samples	2		2		1		2	2									
Sample Point No. 44	4.0	Median	1.0																
		Average			1		0.05		9.6	0.6									
		Maximum	1.0		2				9.8	1.2									
		Minimum	1.0		0				9.4	0									
		No. of Samples	2		2		1		2	2									
Sample Point No. 45	4.5	Median	1.0																
		Average			0		0.05		9.3	0.4									
		Maximum	1.0		0				9.4	0.6									
		Minimum	1.0		0				9.2	0.2									
		No. of Samples	2		2		1		2	2									
From Canadian Shore 3.5 m. east of entrance to SCR to Keewahdin Beach—U. S. Shore Sample Point No. 46	4.75	Median	1.0																
		Average			0		0.05		9.5	0.40									
		Maximum	1.0		0				9.6	0.8									
		Minimum	1.0		0				9.4	0									
		No. of Samples	2		2		1		2	2									
Range continued Sample Point No. 47	4.90	Median	1.0																
		Average			0		0.05		9.0	0.20									
		Maximum	1.0		0				9.4	0.40									
		Minimum	1.0		0				8.6	0									
		No. of Samples	2		2		1		2	2									
	5.0			U. S. Shore															

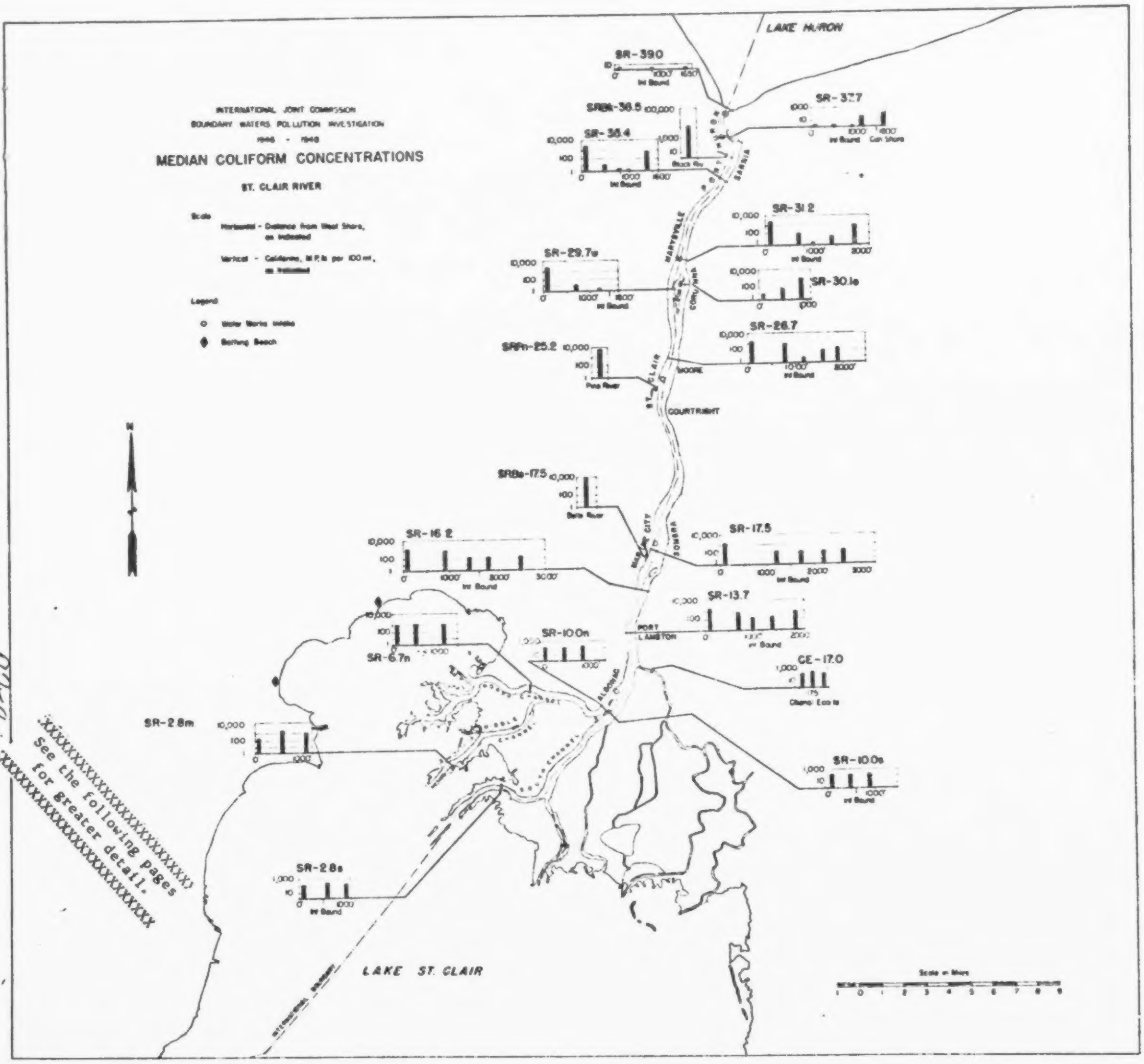

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948
MEDIAN COLIFORM CONCENTRATIONS
ST. CLAIR RIVER
Scale
Horizontal - Distance from West Shore, as indicated
Vertical - Coliforms, M.P.N. per 100 ml, as indicated
Legend
○ Water Works Intake
◆ Bathing Beach
LAKE HURON
LAKE ST. CLAIR
SR-39.0
SRBN-38.5
SR-38.4
SR-37.7
SR-31.2
SR-29.7u
SR-30.1e
SRPn-25.2
SR-26.7
SRBe-17.5
SR-16.2
SR-17.5
SR-13.7
SR-10.0n
SR-6.7n
CE-17.0
SR-2.8m
SR-10.0s
SR-2.8s
SARNIA
MARYSVILLE
CORUNNA
ST. CLAIR
MOORE
COURTRIGHT
MARINE CITY
SOMBRA
PORT LAMBTON
ALGONAC
Black Riv.
Pine River
Belle River
Chenal Ecarte
Int Bound
Can Shore
N
Scale in Miles

Figure 4

xxxxxxxxxxxxxxxxxxxxxx
See the following pages
for greater detail.
xxxxxxxxxxxxxxxxxxxxxx

77-a.

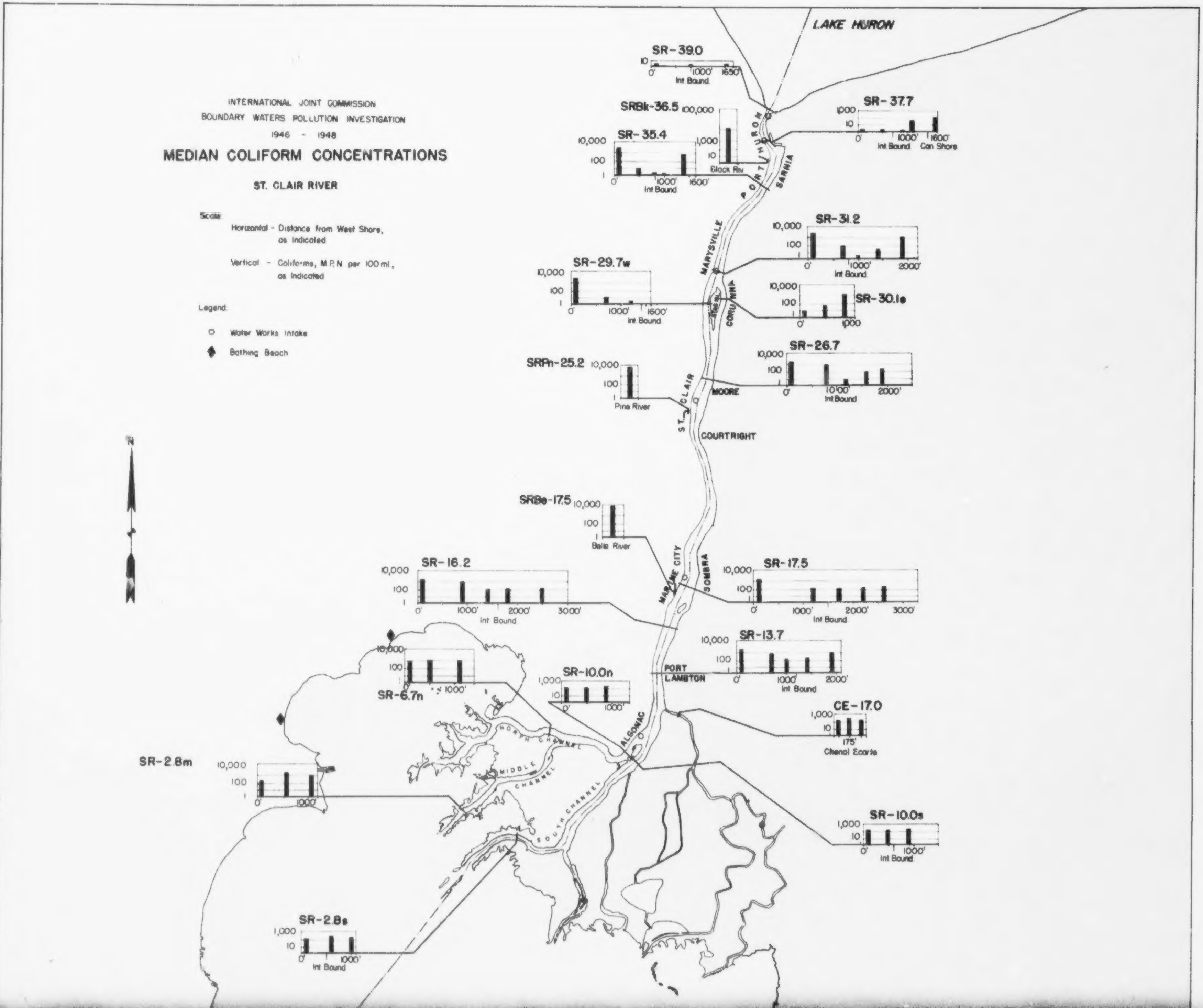
INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948

MEDIAN COLIFORM CONCENTRATIONS

ST. CLAIR RIVER

Scale:
Horizontal - Distance from West Shore, as Indicated
Vertical - Coliforms, M.P.N. per 100 ml, as Indicated

Legend:
○ Water Works Intake
◆ Bathing Beach


LAKE HURON
SR-39.0
Int Bound
SRBk-36.5
Black Riv
SR-35.4
Int Bound
SR-37.7
Int Bound
Can Shore
PORT HURON
SARNIA
MARYSVILLE
CORUNNA
SR-31.2
SR-30.1e
SR-29.7w
SR-26.7
SRPn-25.2
Pine River
ST. CLAIR
MOORE
COURTRIGHT
SRBe-17.5
Belle River
MARINE CITY
SOMBRA
SR-17.5
SR-16.2
SR-13.7
PORT LAMBTON
SR-10.0n
SR-6.7n
CE-17.0
Chenal Ecarte
ALGONAC
NORTH CHANNEL
MIDDLE CHANNEL
SOUTH CHANNEL
SR-2.8m
SR-10.0s
SR-2.8s
N

77-a

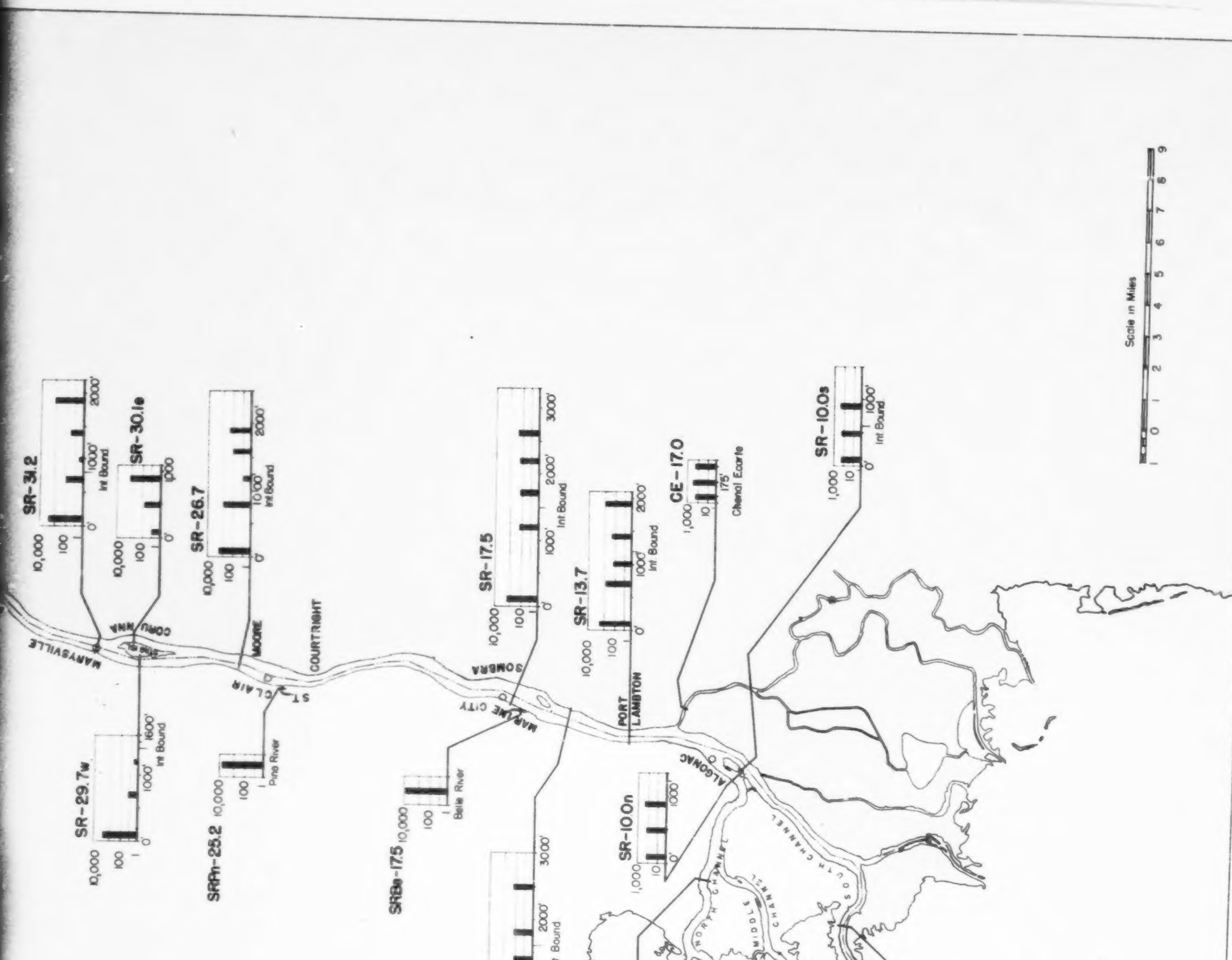
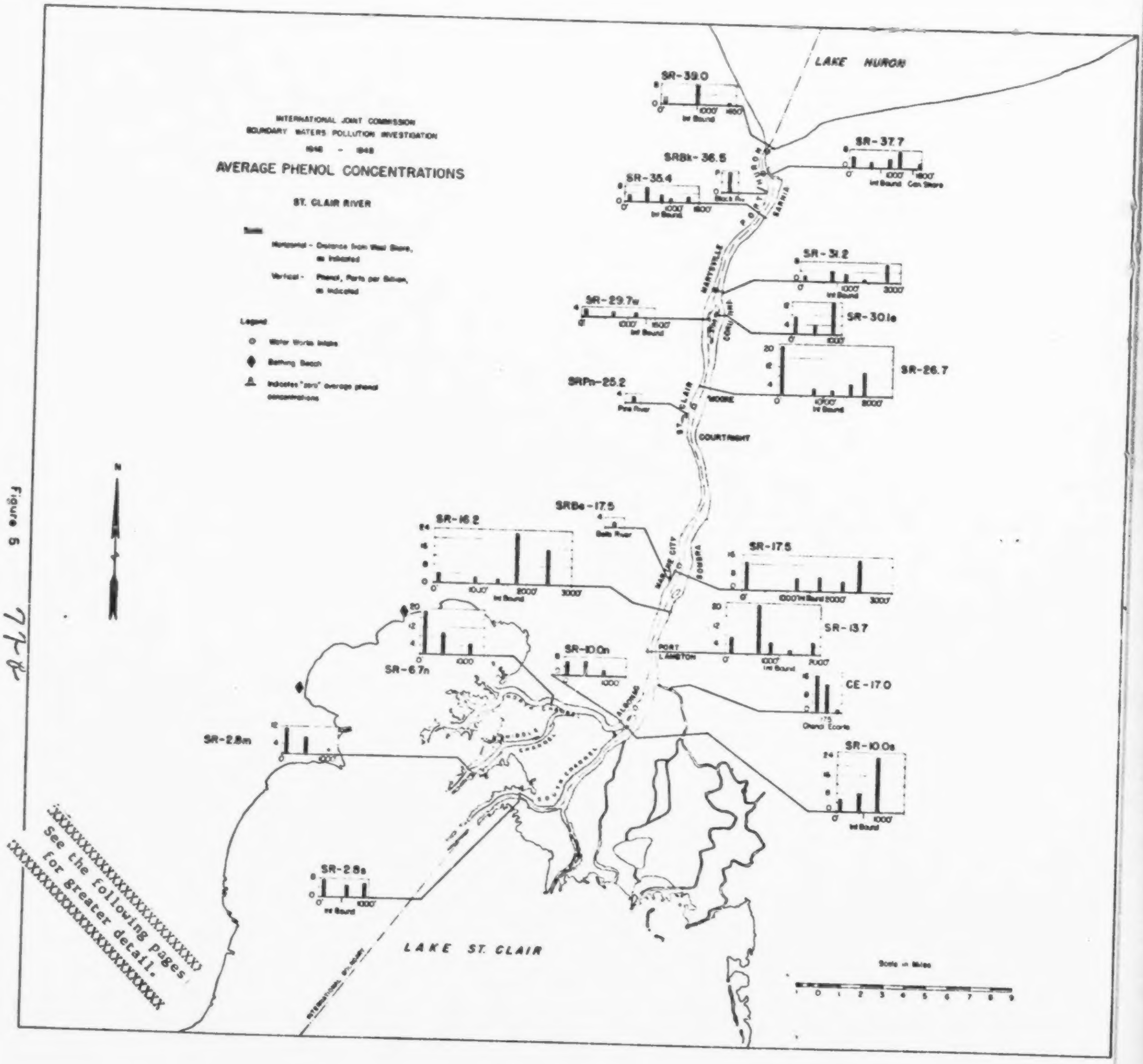

Scale:
Horizontal - Distance from West Shore, as indicated
Vertical - Coliforms, M.P.N per 100 ml, as indicated
Legend
○ Water Works Intake
◆ Bathing Beach
Scale in Miles
0 1 2 3 4 5 6 7 8 9
N
SR-31.2
SR-30.1e
SR-29.7w
SR-26.7
SRPn-25.2
Pine River
SRBe-17.5
Belle River
SR-17.5
SR-16.2
SR-13.7
CE-17.0
Chenal Ecarte
SR-10.0n
SR-10.0s
SR-6.7n
SR-2.8m
SR-2.8s
Int Bound
MARYSVILLE
CORUNNA
ST. CLAIR
MOORE
COURTRIGHT
SOMBRA
MARINE CITY
PORT LAMBTON
ALGONAC
NORTH CHANNEL
MIDDLE CHANNEL
SOUTH CHANNEL
LAKE ST. CLAIR
INTERNATIONAL BOUNDARY

Figure 4

77-a



INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948

AVERAGE PHENOL CONCENTRATIONS

ST. CLAIR RIVER

Scale
Horizontal - Distance from West Shore, as indicated
Vertical - Phenol, Parts per Billion, as indicated

Legend
○ Water Works Intake
◆ Bathing Beach
▲ Indicates "zero" average phenol concentrations

XXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXX

LAKE HURON
SR-39.0
1000'
1600'
Int Bound
SR-37.7
Int Bound
Can Shore
SRBk-36.5
Black Riv.
SR-35.4
PORT HURON
SARNIA
MARYSVILLE
SR-31.2
SR-29.7w
SR-30.1e
CORUNNA
ST. CLAIR
SR-26.7
SRPn-25.2
Pine River
MOORE
COURTRIGHT
SR-16.2
SRBe-17.5
Belle River
MARINE CITY
SOMBRA
SR-17.5
SR-13.7
PORT LAMBTON
SR-10.0n
SR-6.7n
CE-17.0
Chenal Ecarte
ALGONAC
SR-2.8m
SR-10.0s
SR-2.8s
LAKE ST. CLAIR
INTERNATIONAL BOUNDARY
Scale in Miles
0 1 2 3 4 5 6 7 8 9
N

Figure 5

77-R

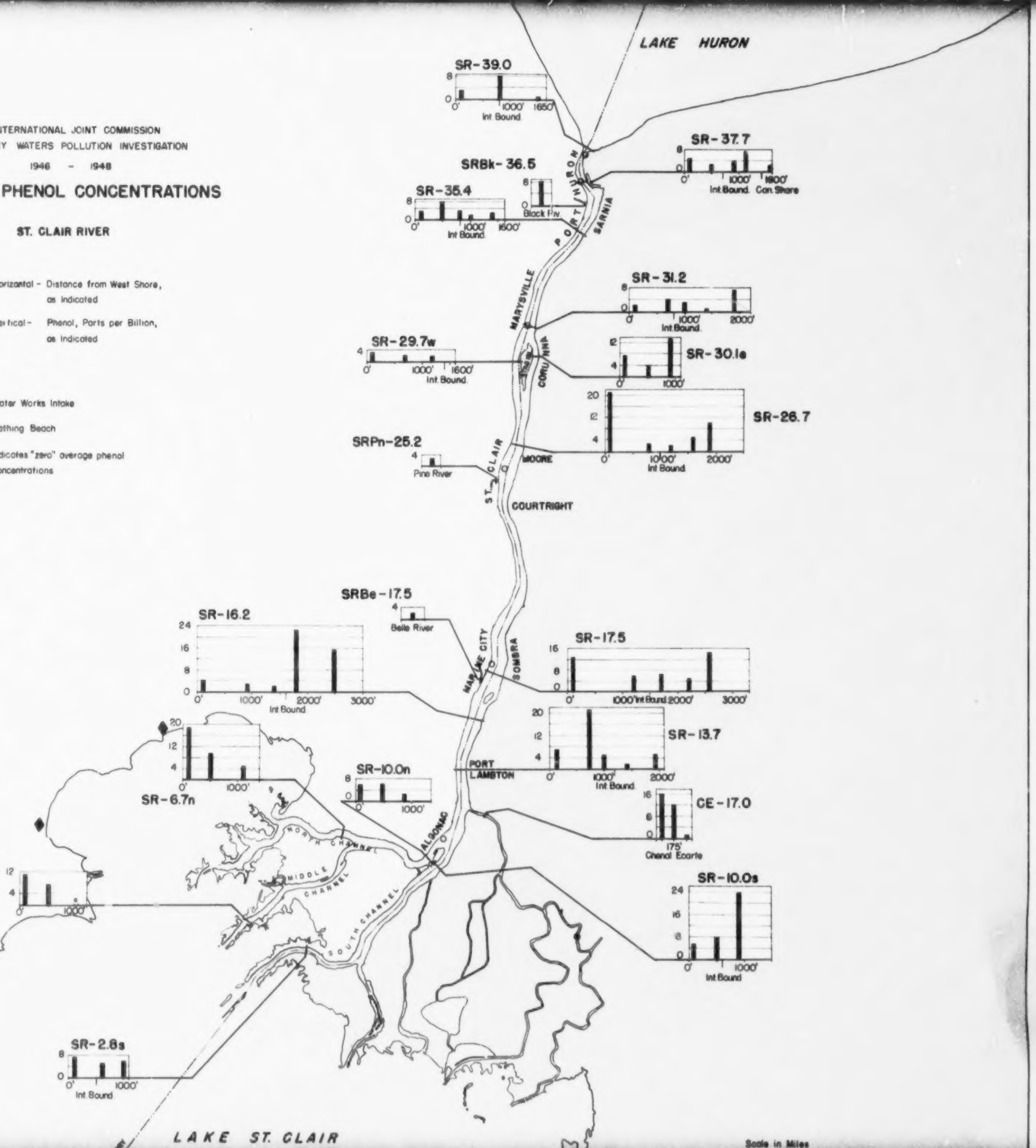
INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948

AVERAGE PHENOL CONCENTRATIONS

ST. CLAIR RIVER

Scale
Horizontal - Distance from West Shore, as indicated
Vertical - Phenol, Parts per Billion, as indicated

Legend
○ Water Works Intake
◆ Bathing Beach
Δ Indicates "zero" average phenol concentrations



LAKE HURON
SR-39.0
8
0
0'
1000'
1650'
Int Bound
SR-37.7
1000'
1600'
Int Bound. Can. Shore
SRBk-36.5
Black Riv.
SR-35.4
1000'
1600'
Int Bound.
PORT HURON
SARNIA
SR-31.2
2000'
MARYSVILLE
CORUNNA
SR-29.7w
4
1600'
SR-30.1e
12
SR-26.7
20
MOORE
SRPn-25.2
Pine River
ST. CLAIR
COURTRIGHT
SRBe-17.5
Belle River
SR-16.2
24
16
3000'
MARINE CITY
SOMBRA
SR-17.5
SR-13.7
PORT LAMBTON
CE-17.0
175'
Chenal Ecarte
SR-6.7n
SR-10.0n
ALGONAC
NORTH CHANNEL
MIDDLE CHANNEL
SOUTH CHANNEL
SR-2.8m
SR-10.0s
SR-2.8s
LAKE ST. CLAIR
Scale in Miles
N

Figure 5

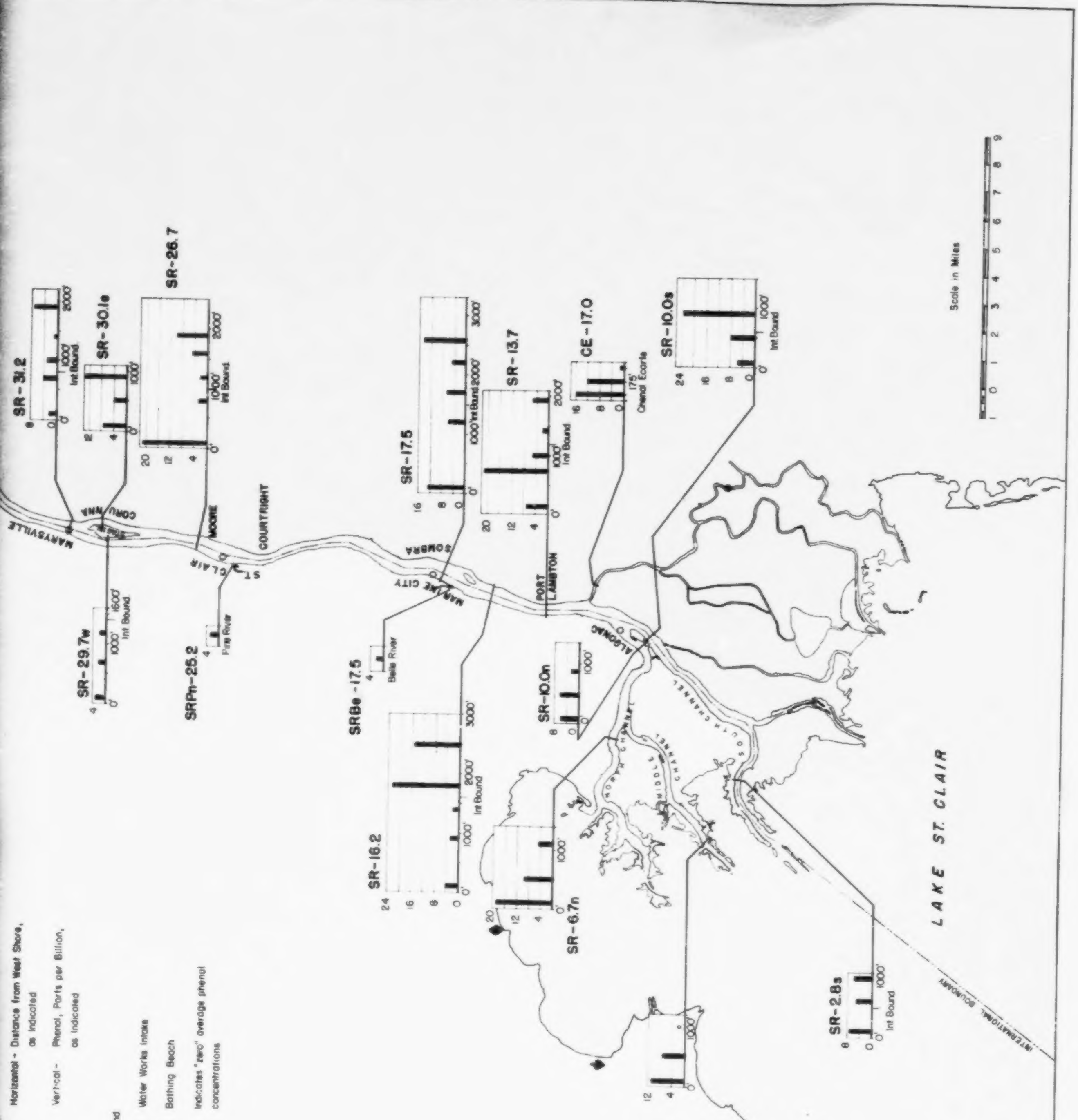

Horizontal - Distance from West Shore, as Indicated
Vertical - Phenol, Parts per Billion, as Indicated
Legend
○ Water Works Intake
◆ Bathing Beach
0 Indicates "zero" average phenol concentrations
N
Scale in Miles
MARYSVILLE
CORUNNA
MOORE
COURTRIGHT
ST. CLAIR
SOMBRA
MARINE CITY
PORT LAMBTON
ALGONAC
NORTH CHANNEL
MIDDLE CHANNEL
SOUTH CHANNEL
LAKE ST. CLAIR
INTERNATIONAL BOUNDARY
SR-31.2
SR-30.1e
SR-29.7w
SR-26.7
SRPn-25.2
Pine River
SR-17.5
SRBe-17.5
Belle River
SR-16.2
SR-13.7
CE-17.0
Chenal Ecarte
SR-10.0s
SR-10.0n
SR-6.7n
SR-2.8m
SR-2.8s
Int Bound

Figure 5

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TABLE 19—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. CLAIR RIVER

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N₂ ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
	SR. 39.0	0.0			U. S. Shore																	
Ft. Gratiot Light to Point Edward Light	SR. 39.0	100	Median	4.1																		
			Average	....	6.0	3.0	.02	.30	17.5	9.7	.68	10	8.0	79	....	....	....	1.3	....	....	....	....
			Maximum	1,100	16.6	40	.18	.31	24.0	11.1	3	34	8.2	82	....	1.3	....	1.3	....	....	200	....
			Minimum	1	2.9	0	0	.29	9.0	6.4	0	2	7.8	78	....	1	....	1.3				
			No. of Samples	20	13	16	10	3	12	19	19	13	3	3	....	3	3	1	....	8	1	....
	SR. 39.0	800			International Boundary																	
	SR. 39.0	800	Median	2.3																		
			Average	....	6.32	8.5	.01	.23	17.0	9.9	.74	11	7.9	79.6	....	0.4	....	1.3	....	....	....	....
			Maximum	9.1	11.3	75	.10	.32	23.5	11.2	3	21	8.1	84	....	1.3	....	1.3	....	....	170	....
			Minimum	1	4.2	0	0	.10	9.0	6.7	0	5	7.8	77	....	0	....	1.3	....	....	....	....
			No. of Samples	17	10	13	7	3	9	15	17	8	3	3	....	3	2	1	....	5	1	....
	SR. 39.0	1,500	Median	<3.6																		
			Average	....	4.9	.82	0	.29	16.5	9.9	.69	9	7.9	79.3	....	1.1	....	1.3	....	....	....	....
			Maximum	170	8.0	10	.04	.31	24.0	11.6	2.3	28	8.2	82	....	1.3	....	1.3	....	....	212	....
			Minimum	<1.8	3.0	0	0	.28	9.0	6.2	0.18	2	7.8	78	....	1	....	1.3	....	....	....	....
			No. of Samples	20	13	17	10	3	12	17	17	11	3	3	....	3	3	1	....	8	1	....
	SR. 39.0	1,650			Canadian Shore																	
		0.0			U. S. Shore																	
Port Huron W. W. to Canadian Shore Dock Ruins to Black Spar	SR. 37.7	100	Median	4.5																		
			Average	....	5.2	4.7	.004	.31	16.0	9.9	.66	7	7.7	80.4	....	1	....	2.2	....	....	....	....
			Maximum	16,000	8.0	60	.04	.42	23.5	11.4	2.6	18	8.0	86	....	4	....	2.2	....	....	178	....
			Minimum	0.67	2.8	0	0	.20	7.5	6.6	0	2	7.4	78	....	0	....	2.2	....	....	....	....
			No. of Samples	27	15	24	10	5	14	21	27	11	5	5	....	5	5	1	....	8	1	....
	SR. 37.7	500	Median	2																		
			Average	....	5.2	2.5	0	.25	15.0	10.1	1.12	8	7.8	79.8	....	1	....	2.2	....	....	....	....
			Maximum	43	8.0	17	0	.30	23.0	11.4	4	19	8.2	82	....	5	....	2.2	....	....	168	....
			Minimum	0.46	3.7	0	0	.10	8.0	6.4	0	4	7.6	77	....	0	....	2.2	....	....	....	....
			No. of Samples	24	11	20	6	5	10	16	21	7	5	5	....	5	5	1	....	5	1	....
	SR. 37.7	700			International Boundary																	

TABLE 19—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. CLAIR RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
Port Huron W. W. to Canadian Shore Dock Ruins to Black Spar (Continued)	SR. 37.7	900	Median	2.5																		
			Average		5.4	3.7	.003	.25	14.5	10.2	.89	7	7.8	79		0						
			Maximum	23	8.0	57	.02	.31	22.5	11.6	2.3	19	8	82		1		1			162	
			Minimum	0.63	4.3	0	0	.10	8.0	6.3	0	4	7.6	77		0		0				
			No. of Samples	25	12	21	7	5	11	19	23	8	5	5		5	4	5		6	1	
	SR. 37.7	1,100	Median	79																		
			Average		5.5	7.5	0	0.24	14.5	10.2	0.83	8	7.9	79.4		0.5						
			Maximum	1,600	8.0	90	0	0.31	22.5	11.6	3.0	18	8.2	82		2		0			184	
			Minimum	<1.8	3.7	0	0	0.05	7.5	6.2	0	5	7.7	78		0		0				
			No. of Samples	24	11	21	6	5	10	16	22	7	5	5		4	4	4		4	1	
	SR. 37.7	1,600	Median	120																		
			Average		6.5	2.1	0	0.25		10.1	0.96	7	7.8	79.6		0						
			Maximum	>18,000	24.0	15.0	0.006	0.30	22.5	11.6	7.0	19	8.4	84		1		0			180	
			Minimum	<3.6	3.1	0	0	0.10	7.5	6.2	0.30	3	7.4	78		0		0				
			No. of Samples	28	14	26	10	5	14	21	27	11	5	5		4	4	3		8	1	
		1,400			Canadian Shore																	
Black River at Mouth	SR. Bk 36.5		Median	16,000																		
			Average		18	8.7		3.7	11.1	5.0	26.6	11	7.2	92		0					225	62
			Maximum	1,100,000	33	35		9.2	13.5	7.5	70	20	7.4	110		0					240	62
			Minimum	16,000	9.1	0		0	9.5	0	2	3	7.0	80		0					210	62
			No. of Samples	10	6	11		8	4	4	10	2	4	6		4					2	1
		0.0																				
Port Huron Coal Dock to Meuller's Dock	SR. 35.4	100	Median	5,400																		
			Average		4.9	3.1	0	0.34	15.0	9.9	0.89	7	7.8	78.8		1.3						
			Maximum	110,000	7.0	55	0	0.40	23.5	11.2	4.0	14	7.9	81		2		1				
			Minimum	45	4.1	0	0	0.27	8.5	6.5	0	3	7.7	77		0		0				
			No. of Samples	29	18	27	10	9	18	26	29	10	8	8		9	9	5		6		
	SR. 35.4	500	Median	13																		
			Average		4.8	6.1	0	0.29		10.2	1.01	8	7.75	78.4		.5						
			Maximum	540	6.6	120	0	0.31	23.5	11.3	6.0	15	7.9	80		2		1				
			Minimum	0.67	3.7	0	0	0.24	8.5	6.2	0	4	7.2	76		0		0				
			No. of Samples	24	14	23	6	9	14	19	23	6	8	8		9	9	7		3		
	SR. 35.4	800	Median	3.6																		
			Average		4.8	3.5	0		13.5	10.2	0.91	6	7.8	77.9		1						

			Maximum	43	6.9	50	0	....	23	11.4	4.4	13	7.9	80	....	1.3	....	1	....	....	....	....
			Minimum	0.67	3.7	0	0	....	8.5	6.4	0	4	7.8	77	....	0	....	0	....	....	....	....
			No. of Samples	25	15	24	7	0	15	23	27	7	8	8	....	9	8	5	....	3	....	....
	SR. 35.4	1,000	Median	2.5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	4.7	1.5	0.17	0.25	14.0	10.3	0.98	7	7.8	78	....	1	....	....	....	....	....	....
			Maximum	540	5.9	23	0.32	0.25	23.0	11.4	4.0	10	7.9	79	....	2.6	....	1	....	....	....	....
			Minimum	0.67	3.9	0	0	0.25	8.5	6.6	0	4	7.7	77	....	0	....	0	....	....	....	....
			No. of Samples	25	14	22	14	1	14	19	22	6	8	8	....	9	8	6	....	3	....	....
	SR. 35.4	1,000	Median	930	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.4	2.6	0	0.25	14.0	10.1	0.96	7	7.8	78.6	....	5	....	....	....	....	....	....
			Maximum	9,200	11.4	15	0	0.32	22.5	11.4	5.0	20	7.9	80	....	40	....	1.3	....	....	....	....
			Minimum	36	3.0	0	0	0.10	8.5	6.3	0	4	7.8	77	....	0	....	0	....	....	....	....
			No. of Samples	29	18	27	10	10	18	26	29	10	8	8	....	9	9	5	....	7	....	....
	SR. 35.4	2,200			Canadian Shore																	
		0.0			U. S. Shore																	
Marysville N. W. to Canadian Oil Co Dock	SR. 31.2	100	Median	4,600	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	9.6	1.8	0	0.31	14.5	9.9	0.78	7	7.7	79.4	....	0.3	....	....	....	....	....	....
			Maximum	92,000	46.0	8	0.004	0.38	24.0	11.4	3.0	13	7.9	80	....	1.1	....	1	....	....	....	....
			Minimum	40	4.0	0	0	0.24	8.5	6.4	0	4	7.6	79	....	0	....	0	....	....	....	....
			No. of Samples	32	20	28	12	9	20	27	31	12	8	8	....	9	8	7	....	7	....	....
	SR. 31.2	700	Median	93	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.0	4.0	0	0.26	14.0	10.3	0.73	8	7.8	78.6	....	1	....	....	....	....	....	....
			Maximum	2,400	6.8	37	0	0.30	23.5	11.4	3.0	12	7.9	80	....	8	....	3.3	....	....	....	....
			Minimum	4.5	4.0	0	0	0.20	7.5	6.6	0	5	7.6	77	....	0	....	0	....	....	....	....
			No. of Samples	27	16	24	8	9	16	24	25	8	8	8	....	9	9	8	....	4	....	....
					International Boundary																	
	SR. 31.2	1,000	Median	4.6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.0	2.9	0.003	0.25	13.5	10.3	0.74	7	7.8	78.2	....	0.1	....	....	....	....	....	....
			Maximum	1,600	6.6	30	0.02	0.31	23.0	11.6	3.6	14	7.9	80	....	1.1	....	1	....	....	....	....
			Minimum	1	4.0	0	0	0.10	7.5	6.2	0	4	7.6	76	....	0	....	0	....	....	....	....
			No. of Samples	28	17	23	9	9	17	24	27	9	8	8	....	9	7	6	....	4	....	....
	SR. 31.2	1,400	Median	41	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.0	0.66	0	0.24	13.0	10.4	0.80	7	7.8	78.6	....	0.3	....	....	....	....	....	....
			Maximum	1,600	6.2	7	0	0.31	23.0	11.8	4.0	14	7.9	80	....	2.6	....	1	....	....	....	....
			Minimum	7.8	3.9	0	0	0.05	7.5	6.3	0	4.0	7.7	78	....	0	....	....	....	....	....	....
			No. of Samples	26	16	24	8	9	17	22	26	8	8	8	....	9	9	1	....	3	....	....
	SR. 31.2	1,900	Median	1,600	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.3	7.6	0	0.28	14.5	10.2	0.92	9	7.8	78.4	....	5	....	....	....	....	....	....
			Maximum	>24,000	6.6	48	0.04	0.32	22.5	11.8	3.5	16	7.9	80	....	40	....	6.7	....	....	....	....
			Minimum	78	4.3	0	0	0.20	7.5	6.5	0	4	7.7	78	....	0	....	....	....	....	....	....
			No. of Samples	32	20	29	12	9	19	28	29	12	8	8	....	9	9	1	....	8	....	....

TABLE 19—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. CLAIR RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
	SR. 31.2	2,200			Canadian Shore																	
		0.0			U. S. Shore																	
Stag Island Middle Light to Stag Island U. S. Channel	SR. 29.7W	100	Median	4,300																		
			Average		8.5	3.1	0	0.29	16.5	9.9	0.72	7	7.7	78.6		1						
			Maximum	>16,000	20.0	30	0.006	0.32	24.0	11.9	2.3	13	7.8	79		2		1				
			Minimum	130	4.1	0	0	0.25	9.0	8.3	0	4	7.7	78		0						
			No. of Samples	16	11	19	8	4	11	14	17	8	3	3		4	4	1		8		
	SR. 29.7W	700	Median	150																		
			Average		5.3	2.2	0	0.26	15.0	10.2	0.59	7	7.8	79								
			Maximum	>2,400	6.6	15	0	0.30	24.0	11.2	3.0	11	7.8	79		1.1		1.1				
			Minimum	2	4.1	0	0	0.20	8.0	8.6	0	4	7.7	79		0						
			No. of Samples	12	8	18	5	4	8	13	15	5	3	3		4	4	1		5		
	SR. 29.7W	1,200	Median	4.6																		
			Average		5.0	2.1	0	0.22	14.5	10.3	0.54	8	7.8	78.3		0.5						
			Maximum	43	6.0	15	0	0.31	23.0	11.4	3.1	9	7.8	79		1		1				
			Minimum	1.8	4.3	0	0	0.10	8.0	8.7	0	6	7.7	78		0						
			No. of Samples	13	7	16	4	4	7	11	14	4	3	3		4	4	1		4		
	SR. 29.7W	1,400			International Boundary																	
	SR. 29.7W	1,600			West Shore of Stag Island																	
		0.0			East Shore of Stag Island																	
Stag Island Ferry Dock to Corruna Ferry Dock (Canadian Channel)	SR. 30.1E	100	Median	17																		
			Average		4.8	7.6	0	0.26	14.5	10.4	0.61	7	7.8	78.3		1						
			Maximum	93	5.4	40	0	0.32	23.0	11.8	2.5	9	7.9	79		1		1				
			Minimum	1.8	4.1	0	0	0.20	7.5	8.7	0	5	7.6	78		0						
			No. of Samples	13	7	17	4	4	7	11	14	4	3	3		4	4	1		2		
	SR. 30.1E	500	Median	93																		
			Average		4.9	3.8	0	0.26	14.5	10.3	0.59	6	7.8	78		10						
			Maximum	1,600	6.0	30	0	0.32	23.0	11.8	2.1	8	7.9	79		40		2.7				
			Minimum	13	3.9	0	0	0.20	7.5	8.7	0	5	7.7	77		0						
			No. of Samples	15	8	19	5	4	8	14	16	5	3	3		4	4	1		5		

	SR. 30.1E	900	Median	2,400	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	5.6	13.8	0	0.26	15.0	10.2	1.02	6	7.8	78.3	...	1	...	...	...	...	...	...
			Maximum	4,600	6.7	140	0	0.30	22.5	11.3	3	10	7.9	79	...	2	...	1	...	...	...	...
			Minimum	220	4.8	0	0	0.20	7.5	8.6	0.16	4	7.6	78	...	0	...	...	...	...	...	...
			No. of Samples	16	11	21	8	4	11	14	17	8	3	3	...	4	4	1	...	8	...	...
	SR. 30.1E	1,100			Canadian Shore																	
		0.0			U. S. Shore																	
Above City of St. Clair to Moore Municipal Dock	SR. 26.7	100	Median	2,400	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	8.1	21	0	0.31	17.5	9.8	0.71	7	7.85	78.5	...	0.3	...	...	...	...	...	...
			Maximum	24,000	13.0	340	0.006	0.32	23.5	11.1	2.4	17	7.9	79	...	1	...	1	...	...	...	...
			Minimum	270	4.5	0	0	0.30	9.0	8.1	0	4	7.8	78	...	0	...	...	...	...	...	...
			No. of Samples	21	10	23		3	10	14	19	8	2	2	...	3	3	1	...	7	...	...
	SR. 26.7	800	Median	930	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	5.8	2.5	0	0.25	16.0	10.1	0.58	9	7.75	78	...	0.3	...	...	...	...	...	...
			Maximum	11,000	6.9	20	0	0.31	23.5	11.2	2.0	14	7.8	78	...	1	...	1	...	...	...	...
			Minimum	14	3.8	0	0	0.15	8.5	8.5	0	4	7.7	78	...	0	...	...	...	...	...	...
			No. of Samples	17	6	20	4	3	6	9	15	4	2	2	...	3	...	1	...	3	...	...
	SR. 26.7	1,000			International Boundary																	
	SR. 26.7	1,200	Median	10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	5.0	2.2	0	0.19	16.0	10.3	0.52	6	7.8	78	...	0.3	...	...	...	...	...	...
			Maximum	79	5.8	25	0	0.30	23.0	11.7	1.8	12	7.9	78	...	1	...	1	...	...	...	...
			Minimum	2	4.2	0	0	0.02	8.5	8.7	0	3	7.7	78	...	0	...	...	...	...	...	...
			No. of Samples	18	7	19	5	3	7	12	16	5	2	2	...	3	3	1	...	4	...	...
	SR. 26.7	1,600	Median	110	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	5.0	4.6	0	0.24	15.5	10.0	0.86	6	7.85	78.5	...	0.3	...	...	...	...	...	...
			Maximum	920	6.0	50	0	0.30	23.0	11.6	2.3	8	7.9	79	...	1.1	...	1.1	...	...	...	...
			Minimum	3.6	4.1	0	0	0.15	8.5	8.6	0	4	7.8	78	...	0	...	...	...	...	...	...
			No. of Samples	17	6	19	4	3	6	9	13	4	2	2	...	3	3	1	...	3	...	...
	SR. 26.7	1,900	Median	490	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	5.3	9.9	0	0.26	16.5	10.1	0.76	5	7.8	78	...	4	...	...	...	...	...	...
			Maximum	4,600	6.0	70	0	0.30	22.5	11.6	2.1	10	7.9	78	...	10	...	1	...	...	...	...
			Minimum	7.8	4.0	0	0	0.20	10	8.3	0	3	7.7	78	...	1	...	...	...	...	...	...
			No. of Samples	21	10	23	8	3	10	16	19	8	2	2	...	3	3	1	...	7	...	...
	SR. 26.7	2,500			Canadian Shore																	
Pine River at Highway M29 Bridge	SR. Pn 25.2		Median	9,300	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	24	2.8	0.08	1.6	4.0	12.0	2.4	61	7.5	87	...	2	...	...	...	...	...	...
			Maximum	460,000	60	15	0.38	2.0	16.5	14.1	6.5	309	7.8	130	...	4	...	...	...	...	...	...
			Minimum	1,500	9.1	0	0	1.2	0	8.3	0.65	5	7.4	60	...	1	...	...	...	...	...	...
			No. of Samples	15	16	16	16	4	16	16	16	13	16	16	...	15	...	...	...	...	...	...
		0.0			U. S. Shore Line																	

TABLE 19—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. CLAIR RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
American Shore to Courtright	SR. 24.2	100	Median	4,300																		
			Average	....	12.0	2.0	0	....	19.0	9.1	0.15	5.5	....	....	....	....	....	....	....	....	....	....
			Maximum	7,500	16.0	8.0	0	....	19.5	9.4	0.44	6.0	....	....	....	....	....	....	....	....	....	....
			Minimum	2,400	8.2	0	0	....	18.0	8.8	0.28	5.0	....	....	....	....	....	....	....	....	....	....
			No. of Samples	4	4	4	4	....	4	4	4	4	....	....	....	....	....	....	....	....	....	....
	SR. 24.2	1,100			International Boundary																	
	SR. 24.2	2,000	Median	930																		
			Average	....	5.7	3.7	0	....	17.5	9.6	0.44	5.0	....	....	....	....	....	....	....	....	....	....
			Maximum	2,400	6.1	15.0	0	....	19.0	9.9	0.56	5.0	....	....	....	....	....	....	....	....	....	....
			Minimum	430	5.4	0	0	....	16.5	9.3	0.35	5.0	....	....	....	....	....	....	....	....	....	....
			No. of Samples	4	4	4	4	....	4	4	4	4	....	....	....	....	....	....	....	....	....	....
	SR. 24.2	2,100			Canadian Shore																	
		0.0			U. S. Shore																	
Marine City Ferry Dock to Sombra Ferry Dock	SR. 17.5	100	Median	1,700																		
			Average	....	8.6	12	0.004	0.24	18.0	9.8	0.89	8.0	7	....	....	0.5	....	....	....	....	....	....
			Maximum	9.300	11.0	160	0.04	0.32	24.0	10.9	4	15	7.9	79	....	1	....	1	....	....	....	....
			Minimum	350	4.7	0	0	0.15	10.0	8.4	0	4	....	....	....	0	....	....	....	....	....	....
			No. of Samples	22	10	23	9	2	10	16	20	9	1	1	....	2	2	1	....	7	....	....
	SR. 17.5	1,200	Median	180																		
			Average	....	7.5	5.4	.0008	0.26	19.0	10.1	0.76	9	....	....	....	0.5	....	....	....	....	....	....
			Maximum	24,000	10.0	60	.004	0.31	23.5	11.2	1.9	12	7.9	78	....	1	....	1	....	....	....	....
			Minimum	11	5.8	0	0	0.20	15.0	8.5	0	5	....	....	....	0	....	....	....	....	....	....
			No. of Samples	18	6	19	5	2	5	8	16	6	1	1	....	2	2	1	....	3	....	....
	SR. 17.5	1,500			International Boundary																	
	SR. 17.5	1,700	Median	170																		
			Average	....	5.5	6.1	0.01	0.25	17.0	10.1	0.96	8	....	....	....	0.5	....	....	....	....	....	....
			Maximum	2,100	5.9	30	0.06	0.30	23.0	11.3	3.0	16	7.9	79	....	1.1	....	1	....	....	....	....
			Minimum	13	5.1	0	0	0.20	9.5	8.5	0	4	....	....	....	0	....	....	....	....	....	....
			No. of Samples	19	7	20	6	2	7	11	18	6	1	1	....	2	....	1	....	4	....	....
	SR. 17.5	2,200	Median	240																		
			Average	....	5.3	4.4	.0008	0.23	17.0	10.2	0.87	7	....	....	....	1	....	....	....	....	....	....
			Maximum	4,600	5.8	15	0.004	0.30	23.0	11.4	2.4	10	7.9	79	....	1.1	....	1	....	....	....	....
			Minimum	13	4.7	0	0	0.15	9.5	8.6	0	5	....	....	....	0	....	....	....	....	....	....
			No. of Samples	18	6	19	5	2	6	9	17	5	1	1	....	3	3	1	....	3	....	....

	SR. 17.5	2,600	Median	430																		
			Average		5.1	13.8	.0009	.30	17.0	10	0.86	6				0.5						
			Maximum	>2,400	5.8	80	.008	.30	23.0	11.5	4.0	9	7.9	78		1.1		1				
			Minimum	130	3.9	0	0	.30	13.5	8.6	0	3				0						
			No. of Samples	22	10	23	9	2	10	14	20	9	1	1	....	2	2	1	....	7	....	....
	SR. 17.5	3,300			Canadian Shore																	
Belle River at Highway M29 Bridge	SR. Be 17.5		Median	9,300																		
			Average		20	2	0.14	1.3	4.9	10.4	2.1	71	7.7	150		1.6						
			Maximum	93,000	45	18	0.34	1.5	17.5	12.4	3.8	375	8.0	270		5						
			Minimum	910	6.5	0	0	1.1	0	8.0	0.88	4	7.2	84		1						
			No. of Samples	19	18	18	18	4	19	19	19	14	18	18	...	17						
		0.0			U. S. Shore																	
Above Salt Dock Light to Canadian Shore (below Woodtick Island)	SR. 16.2	100	Median	2,400																		
			Average		7.2	4.4	.002	0.31	18.0	9.8	0.52	9				1.5						
			Maximum	>24,000	10.3	25	.02	0.31	24.0	10.9	1.7	15	7.8	77		2		1				
			Minimum	790	1.1	0	0	0.30	10	8.4	0	6				1.1						
			No. of Samples	16	11	19	10	2	11	16	17	10	1	1	....	2	2	1	...	26	....	....
	SR. 16.2	900	Median	930																		
			Average		6.4	2.7	0.027	0.24	17.0	10.1	0.64	10				1						
			Maximum	11,000	8.2	10	0.16	0.29	23.5	11.5	2.5	18	7.8	79		1.1		1				
			Minimum	350	4.3	0	0	0.20	10.0	8.5	0	4				1						
			No. of Samples	12	7	15	6	2	7	9	12	6	1	1	....	2	2	1	....	3	....	....
	SR. 16.2	1,400	Median	150																		
			Average		5.3	2.4	.03	0.20	17.0	10.1	0.6	8				0.5						
			Maximum	4,600	6.2	10	0.24	0.29	23.0	11.5	2	14	7.8	77		1.1		1				
			Minimum	13	4.8	0	0	0.1	10.0	8.6	0	5				0						
			No. of Samples	13	8	16	7	2	8	11	14	7	1	1	....	2	....	1	....	4	....	....
	SR. 16.2	1,600			International Boundary																	
	SR. 16.2	1,800	Median	200																		
			Average		5.1	22.5	.001	.24	17.0	10.2	.61	7										
			Maximum	930	5.6	260	.006	.28	23.0	11.5	2.7	10	7.8	77		1.1		1				
			Minimum	79	4.5	0	0	.20	10.0	8.6	0	4										
			No. of Samples	12	7	15	6	2	7	11	12	6	1	1	....	1	....	1	....	4	....	....
	SR. 16.2	2,500	Median	320																		
			Average		4.9	15	.01	.22	17.5	10.1	.74	7				1						
			Maximum	1,100	5.8	175	.10	.28	23.0	11.6	4	13	7.9	79		1		1				
			Minimum	170	4.0	0	0	.15	10.0	9.3	0	4				1						
			No. of Samples	16	11	19	10	2	11	15	15	10	1	1	....	2	2	1	....	7	....	....
	SR. 16.2	3,000	....	....	Canadian Shore																	

TABLE 19—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. CLAIR RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
		0.0			U. S. Shore																	
Robert's Landing to Port Lambton Ferry Dock	SR. 13.7	100	Median	2,400																		
			Average		7.9	7.1	.001	.25	16.5	9.9	0.84	9										
			Maximum	110,000	11.0	35	.01	.35	24.0	11.0	3	18	7.8	79		1		1			138	34
			Minimum	23	6.0	0	0	.10	10.0	8.3	0	4										
			No. of Samples	28	14	27	13	3	14	20	25	14	1	1		1	1	1		8	1	1
	SR. 13.7	700	Median	840																		
			Average		6.9	21.7	.025	.22	16.0	10.2	.74	7										
			Maximum	15,000	9.0	400	.18	.30	24.0	11.3	4	18	7.9	79		1		1			126	30
			Minimum	79	5.2	0	0	.10	10.0	8.6	0	3				0						
			No. of Samples	24	10	24	9	3	10	12	21	10	1	1		2	2	1		4	1	1
	SR. 13.7	1,000	Median	170																		
			Average		5.6	5.1	0	.25	16.0	10.2	0.9	7				0.5						
			Maximum	11,000	6.0	25	0	.35	23.5	11.4	3	11	7.9	78		1 1		1			76	
			Minimum	0	4.9	0	0	.10	10.0	8.6	0	4				0						
			No. of Samples	26	11	25	10	3	11	15	23	11	1	1		2	2	1		5	1	
	SR. 13.7	1,200			International Boundary																	
	SR. 13.7	1,400	Median	290																		
			Average		5.2	1.9	0	.25	15.5	10.3	.75	6										
			Maximum	1,100	5.8	12.0	0	.39	23.0	11.6	3.0	15	7.8	79		1		1			122	44
			Minimum	60	4.5	0	0	.10	10.0	8.6	0	2				0						
			No. of Samples	24	10	22	9	3	10	12	20	11	1	1		2	2	1		4	1	1
	SR. 13.7	1,900	Median	860																		
			Average		5.1	5.5	0	.28	16.0	10.2	.68	7				0.5						
			Maximum	2,400	6.4	35	0	.36	23.0	11.6	3.0	11	7.8	79		1		1			142	60
			Minimum	<1.8	4.0	0	0	.20	10.0	8.9	0	4				0						
			No. of Samples	28	14	28	13	3	14	19	24	14	1	1		2	2	1		8	1	1
	SR. 13.7	2,100			Canadian Shore																	
		00			U. S. Shore (Mainland)																	
North Channel Below Russel Island and Algonac	SR. 10.0N	100	Median	1,600																		
			Average		6.8	5.7	0	.23	16.5	9.9	.61	8	7.8	79		1						
			Maximum	46,000	8.8	60	0	.30	24.0	11.1	3	13	7.8	78		1		1				
			Minimum	130	4.2	0	0	.10	10.0	8.4	0	2	7.8	78		0						
			No. of Samples	30	15	25	13	3	15	19	22	13	2	2		3	3	1		8		

	SR. 10.0N	500	Median	430																		
			Average		5.9	3.6	0	.17	15.5	10.2	.79	8	7.8	79								
			Maximum	4,600	8.0	60	0	.30	23.5	11.1	4	13	7.8	80		1		1				
			Minimum	45	4.5	0	0	.05	10.0	8.5	0	4	7.8	78		0						
			No. of Samples	27	12	23	10	4	12	14	20	10	2	2	....	4	4	2	....	6	....	....
	SR. 10.0N	900	Median	140																		
			Average		5.1	2.6	0	.22	15.5	10.3	5.5	7	7.8	78								
			Maximum	11,000	7.8	30	0	.29	23.5	11.8	2.6	12	7.8	78		1.1		1				
			Minimum	49	3.8	0	0	.10	10.0	8.7	0	4	7.8	78		0						
			No. of Samples	24	11	21	9	3	11	12	19	9	2	2	....	3	3	1	....	4	....	....
	SR. 10.0N	1,400			East Side of North Channel (U. S.) (Harsens Island)																	
		00			U. S. Shore																	
South Channel Below Russell Island	SR. 10.0S	100	Median	240																		
			Average		5.1	5.3	0	.25	15.0	10.3	.70	6	7.8	79		0.5						
			Maximum	2,400	6.0	30	0	.32	23.5	11.4	2.6	8	7.8	80		1		1				
			Minimum	12	4.4	0	0	.10	7.0	8.7	0	4	7.8	78		0						
			No. of Samples	24	9	18	6	4	9	13	15	6	3	2	....	4	4	1	....	3	....	....
	SR. 10.0S	500	Median	240																		
			Average		5.1	7.6	0	.24	15.0	10.3	.8	7	7.8	78		0.5						
			Maximum	>2,400	6.0	85	0	.28	23.5	11.4	2.6	9	7.9	79		1		1				
			Minimum	9.3	4.6	0	0	.10	10.0	8.6	0	5	7.8	78		0						
			No. of Samples	25	10	19	7	4	10	14	18	7	3	3	....	4	4	1	....	4	....	....
	SR. 10.0S	600			International Boundary																	
	SR. 10.0S	900	Median	430																		
			Average		4.7	24	.02	.23	16.0	10.2	.62	8	7.8	79		0.5						
			Maximum	4,600	5.5	410	.16	.31	23.5	11.5	2.4	18	7.9	79		1		1				
			Minimum	70	2.6	0	0	.05	7.0	8.7	0	4	7.8	78		0						
			No. of Samples	27	13	22	10	4	13	14	20	10	3	3	....	4	4	1	....	7	....	....
	SR. 10.0S	1,500			Canadian Shore—West Side (Walpole Island)																	
		90			U. S. Shore																	
South Channel Below Tashmoo Park	SR. 6.0S	100	Median	240																		
			Average		5.2	10	.05	.19	17.5	10.4	.58	5				0.5						
			Maximum	4,600	6.0	50	.14	.29	23.5	12.5	1.5	9	7.8	79		1		1			122	44
			Minimum	130	4.0	0	0	.10	10.0	8.6	.20	2				0						
			No. of Samples	6	5	7	3	3	5	6	6	5	1	1	....	2	2	1	....	2	1	1
	SR. 6.0S	400	Median	240																		
			Average		5.2	4.5	0	.23	17.5	10.3	.46	5				0.5						
			Maximum	4,600	5.6	13	0	.29	23.5	12.1	1.30	8	7.8	79		1		1			154	80
			Minimum	130	4.4	0	0	.10	10.0	8.6	.10	4				0						
			No. of Samples	7	6	8	5	3	6	7	7	6	1	1	....	2	2	1	....	3	1	1

TABLE 19—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. CLAIR RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N₂ ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
South Channel Below Tashmoo Park (Continued)	SR. 6.0S	700	Median	340	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.0	22	.0012	.20	17.5	10.0	.55	6	....	....	....	....	....	....	....	....	....	....
			Maximum	930	5.8	100	.01	.29	23.5	12.3	1.9	12	7.8	79	....	1	....	1	....	....	150	58
			Minimum	140	3.3	0	0	.10	10.0	8.7	.26	4	....	....	....	0	....	....	....	....	....	....
			No. of Samples	10	9	11	8	3	9	10	10	9	1	1	....	2	2	1	....	6	1	1
	SR. 6.0S	900			International Boundary																	
	SR. 6.0S	2,300			Canadian Shore																	
		00			U. S. Shore																	
South Channel Light No. 27 to Canada Club	SR. 5.0S	100	Median	490	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.0	2.5	.003	.29	18.0	10.3	.38	7	....	....	....	....	....	....	....	....	....	....
			Maximum	4,600	6.0	5	.01	.29	23.0	11.3	.51	10	7.8	79	....	0	....	....	....	....	....	....
			Minimum	170	4.5	0	0	.29	10.0	8.6	.12	5	....	....	....	0	....	....	....	....	....	....
			No. of Samples	4	4	4	3	1	4	4	4	3	1	1	....	2	2	....	....	1	....	....
	SR. 5.0S	500	Median	430	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.1	34	0	.29	16.0	10.2	.45	7	....	....	....	....	....	....	....	....	....	....
			Maximum	>2,400	6.0	160	0	.29	23.5	11.3	.55	13	7.8	78	....	0	....	....	....	....	....	....
			Minimum	210	3.9	0	0	.29	10.0	8.7	.27	4	....	....	....	....	....	....	....	....	....	....
			No. of Samples	5	5	5	4	1	5	5	5	4	1	1	....	1	1	....	....	2	....	....
	SR. 5.0S	500			International Boundary																	
	SR. 5.0S	900	Median	390	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	4.6	5.5	0	.28	17.0	9.9	0.33	6	....	....	....	....	....	....	....	....	....	....
			Maximum	2,400	6.0	18	0	.28	23.0	11.3	0.7	8	7.8	78	....	0	....	....	....	....	....	....
			Minimum	240	1.6	0	0	.28	10.0	8.7	0.03	4	....	....	....	....	....	....	....	....	....	....
			No. of Samples	8	8	8	7	1	8	8	8	7	1	1	....	1	1	....	....	5	....	....
	SR. 5.0S	1,150			Canadian Shore																	
		00			U. S. Shore																	
South Channel at Light No. 17 Below Forster	SR. 2.8S	100	Median	240	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.0	9	0	....	13.0	10.5	.37	11	....	....	....	....	....	....	....	....	....	....
			Maximum	930	6.2	30	0	....	16.0	10.8	0.58	23	....	....	....	....	....	....	....	....	....	....
			Minimum	210	4.0	0	0	....	11.0	10.1	0.13	5	....	....	....	....	....	....	....	....	....	....
			No. of Samples	7	7	7	7	....	5	7	7	7	....	....	....	....	....	....	....	3	....	....
	SR. 2.8S	300	Median	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

			Maximum	2,400	3.9	0	0	...	14.5	10.4	0.38	8	...	...	...	...	...	...	...	...	...	...
			Minimum	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			No. of Samples	1	1	1	1	...	1	1	1	1	...	...	...	...	...	...	...	...	...	...
	SR. 2.8S	500	Median	430	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	5.5	4	0	...	14.5	10.6	.43	12	...	...	...	...	...	...	...	...	...	...
			Maximum	930	6.9	10	0	...	14.5	10.8	0.52	16	...	...	...	...	...	...	...	...	...	...
			Minimum	210	4.6	0	0	...	14.5	10.5	0.29	7	...	...	...	...	...	...	...	...	...	...
			No. of Samples	3	3	3	3	...	1	3	3	3	...	...	...	...	...	...	...	...	...	...
	SR. 2.8S	600			International Boundary																	
	SR. 2.8S	600	Median	750	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	4.9	6	0	...	13.0	10.4	0.37	7	...	...	...	...	...	...	...	...	...	...
			Maximum	930	5.1	30	0	...	16.0	10.5	0.53	11	...	...	...	...	...	...	...	...	...	...
			Minimum	230	4.8	0	0	...	11.0	10.3	0.23	5	...	...	...	...	...	...	...	...	...	...
			No. of Samples	4	5	5	5	...	5	5	5	5	...	...	...	...	...	...	...	1	...	...
	SR. 2.8S	700	Median	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Maximum	430	5.1	0	0	...	14.0	10.5	0.64	8	...	...	...	...	...	...	...	...	...	...
			Minimum	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			No. of Samples	1	1	1	1	...	1	1	1	1	...	...	...	...	...	...	...	...	...	...
	SR. 2.8S	1,000	Median	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Maximum	430	5.0	2	0	...	...	10.6	0.42	16	...	...	...	...	...	...	...	...	...	...
			Minimum	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			No. of Samples	1	1	1	1	...	...	1	1	1	...	...	...	...	...	...	...	...	...	...
	SR. 2.8S	1,100	Median	430	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	4.8	7	0	...	13.1	10.4	0.35	6	...	...	...	...	...	...	...	...	...	...
			Maximum	930	5.0	35	0	...	15.0	10.5	0.68	10	...	...	...	...	...	...	...	...	...	...
			Minimum	230	4.0	0	0	...	11.0	10.3	0.22	3	...	...	...	...	...	...	...	...	...	...
			No. of Samples	5	5	5	5	...	5	5	5	5	...	...	...	...	...	...	...	3	...	...
	SR. 2.8S	1,200			Canadian Shore																	
		00			U. S. Shore																	
North Channel at Pearl Beach	SR. 6.7S	100	Median	930	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	5.8	18.6	.009	.20	17.0	9.9	.32	7	...	...	...	0.5	...	...	...	...	...	...
			Maximum	11,000	7.8	160	.01	.29	24.0	11.1	.62	8	7.8	79	...	1	...	1	...	...	...	...
			Minimum	130	4.1	0	0	.10	10.0	8.5	0	5	...	...	...	0	...	...	...	...	...	...
			No. of Samples	14	12	15	11	2	12	13	13	11	1	1	...	2	2	1	...	8	...	...
	SR. 6.7N	500	Median	1,100	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	5.9	9.4	0	.19	16.0	10.1	.48	7	...	...	...	...	...	...	...	...	...	...
			Maximum	24,000	7.6	35	0	.28	24.0	11.1	2.1	8	7.9	78	...	1	...	1	...	...	...	...
			Minimum	49	5.2	0	0	.10	10.0	8.5	0	5	...	...	...	0	...	...	...	...	...	...
			No. of Samples	11	9	12	8	2	9	10	11	8	1	1	...	2	2	1	...	5	...	...

TABLE 19—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. CLAIR RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
North Channel at Pearl Beach (Continued)	SR 6.7N	1,100	Median	1,300	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	6.2	5.1	0	.19	16.0	10.3	.31	6	....	....	....	....	....	....	....	....	....	....
			Maximum	>24,000	7.0	36	0	.28	23.5	11.1	.56	8	7.8	78	....	1	....	1	....	....	....	....
			Minimum	430	4.9	0	0	.10	10.0	8.5	0	4	....	....	....	0	....	....	....	....	....	....
			No. of Samples	10	8	11	7	2	8	10	9	6	1	1	....	2	2	1	....	3	....	....
	SR. 6.7N	1,400			East Shore (U. S.) (Dickinson Island)																	
		00			U. S. Shore (Dickinson (Island)																	
Middle Channel Below North Channel at Pearl Beach	SR. 6.7M	400	Median	430	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.6	3.6	0	.19	17.0	9.9	.38	7	....	....	....	....	....	....	....	....	....	....
			Maximum	4,600	7.1	48	0	.28	24.0	11.2	1.0	9	7.8	79	....	1	....	1	....	....	....	....
			Minimum	130	4.8	0	0	.10	10.0	8.4	.13	4	....	....	....	0	....	....	....	....	....	....
			No. of Samples	15	13	16	12	2	13	14	14	12	1	1	....	2	2	1	....	9	....	....
	SR. 6.7M	800			U. S. Shore (Harsens Island)																	
		00			Dickenson Island Side																	
Middle Channel Above Big Fisher Highway	SR. 2.8M	100	Median	430	....	....	....		....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.6	14	0	....	13.5	10.3	.27	7	....	....	....	....	....	....	....	....	....	....
			Maximum	11,000	6.2	50	0	....	16.0	10.4	0.33	8	....	....	....	....	....	....	....	....	....	....
			Minimum	230	5.2	0	0	....	11.0	10.2	0.15	6	....	....	....	....	....	....	....	....	....	....
			No. of Samples	4	4	4	4	....	4	4	4	4	....	....	....	....	....	....	....	2	....	....
	SR. 2.8M	300	Median	....	....	....	....		....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	....	....	....		....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Maximum	2,400	4.8	0	0	....	15.5	10.4	0.36	7	....	....	....	....	....	....	....	....	....	....
			Minimum	....	....	....	....		....	....	....	....	....	....	....	....	....	....	....	....	....	....
			No. of Samples	1	1	1	1	....	1	1	1	1	....	....	....	....	....	....	....	....	....	....
	SR. 2.8M	500	Median	....	....	....	....		....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	....	....	....		....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Maximum	2,400	4.6	0	0	....	14.5	10.4	0.48	7	....	....	....	....	....	....	....	....	....	....
			Minimum	....	....	....	....		....	....	....	....	....	....	....	....	....	....	....	....	....	....
			No. of Samples	1	1	1	1	....	1	1	1	1	....	....	....	....	....	....	....	....	....	....
	SR. 2.8M	600	Median	930	....	....	....		....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.3	6	0	....	13.0	10.4	0.35	7	....	....	....	....	....	....	....	....	....	....
			Maximum	2,400	6.0	20	0	....	15.0	10.5	0.38	8	....	....	....	....	....	....	....	....	....	....

			Minimum	460	4.4	0	0	.....	11.0	10.3	0.30	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			No. of Samples	4	4	4	4	.....	4	4	4	4	.....	.....	.....	.....	.....	.....	.....	2	.....	.....
	SR. 2.8M	700	Median	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Average	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Maximum	4,600	4.4	0	0	.....	14.0	10.3	0.44	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Minimum	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			No. of Samples	1	1	1	1	.....	1	1	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	SR. 2.8M	1,100	Median	930	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Average	.....	5.5	0	0	.....	13.0	10.3	0.36	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Maximum	11,000	5.8	0	0	.....	15.0	10.5	0.40	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Minimum	230	5.0	0	0	.....	11.0	10.2	0.24	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			No. of Samples	4	4	4	4	.....	4	4	4	4	.....	.....	.....	.....	.....	.....	.....	2	.....	.....
	SR. 2.8M	1,200			Harsens Island Side																	
		0.0			Mainland Side 2½ Miles West 7 Pearl Beach																	
North Channel Above Chenal A Bout Rand	SR. 4.3N	400	Median	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Average	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Maximum	2,400	5.5	0	0	.....	15.0	10.4	0.62	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Minimum	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			No. of Samples	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	SR. 4.3N	500	Median	2,300	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Average	.....	6.2	tr.	0	.....	14.0	10.3	0.35	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Maximum	9,300	6.9	3	0	.....	17.0	10.4	0.41	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Minimum	750	5.9	0	0	.....	12.0	10.2	0.31	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			No. of Samples	4	4	4	4	.....	4	4	4	4	.....	.....	.....	.....	.....	.....	.....	1	.....	.....
	SR. 4.3N	600	Median	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Average	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Maximum	750	5.8	0	0	.....	14.5	10.4	0.55	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Minimum	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			No. of Samples	1	1	1	1	.....	1	1	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	SR. 4.3N	800	Median	2,300	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Average	.....	5.4	24	0	.....	14.0	10.3	0.35	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Maximum	24,000	7.0	120	0	.....	15.0	10.4	0.40	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Minimum	930	4.2	0	0	.....	12.0	10.1	0.24	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			No. of Samples	5	5	5	5	.....	5	5	5	5	.....	.....	.....	.....	.....	.....	.....	1	.....	.....
	SR. 4.3N	1,000	Median	930	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Average	.....	5.9	0	0	.....	13.5	10.3	0.40	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Maximum	2,400	6.8	0	0	.....	15.5	10.5	0.44	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			Minimum	430	5.1	0	0	.....	12.0	10.2	0.34	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
			No. of Samples	4	4	4	4	.....	4	4	4	4	.....	.....	.....	.....	.....	.....	.....	1	.....	.....

the United States shore increased from 5 above the Black River to 5,400 below Port Huron. The coliform results at the mouth of the Black River showed a median M.P.N. value of 16,000 per 100 ml., and a maximum of over 1,100,000. Thus, the Black River introduces a heavy coliform concentration in spite of any intended beneficial effect of the canal feeding Lake Huron water into this river. Near the Canadian shore the M.P.N. values increased from 5 at the entrance of the river to 930 below Sarnia and further rose to 2,400 at Corunna.

Proceeding downstream from St. Clair and Moore, the coliform results show a pronounced development toward a uniform distribution across the entire river. Between St. Clair and Marine City the stream is considerably reduced in cross-section, causing a swifter current and increased turbulence. This tends to mix the water and partially diffuse the polluting matter, a conclusion which was supported by surface float studies. The bacterial load is sustained at a high level of 2,400 M.P.N. on the United States side by raw sewage introduced at St. Clair and Marine City. At a corresponding point on the Canadian side, the bacterial load shows some diminution but continues at a moderately high level of 860 M.P.N.

As the flow divides in the vicinity of Algonac the band of shore pollution from the United States side is carried into the North and Middle Channels, and from the Canadian side into the Chenal Ecarte. The flow of the less concentrated band in the center of the St. Clair River tends to follow the South Channel into Lake St. Clair.

The water leaving the St. Clair River carries a bacterial load of coliform organisms 200 times greater than the same water as it enters from Lake Huron. This condition prevails in spite of the effects of natural purification in this stretch of 28 miles.

Phenols are not normally present in clean waters. Lake Huron water, for the most part, was free from this substance. An occasional sample, taken from the navigation channel showed phenol, but the source of this was uncertain.

Since phenols come almost entirely from industrial plants these discharges will not necessarily be uniform. This is demonstrated by the variable results obtained in the river samples. High values were found on both sides. These can be attributed, on the Canadian side, to known sources. However, high values on the United States side could not be traced to known sources on that side. They may be due to slugs from some unknown origin. In the upper reaches of the river a maximum of 140 p.p.b. was found on the Canadian side, and a maximum of 340 p.p.b. on the United States side.

Below the constricted section there is evidence of diffusion and distribution in the central band of the stream. All channels leading from the St. Clair River carry varying amounts of phenol. A few high results, ranging from 160 to 400 p.p.b., were obtained in the North and South Channels, respectively, and 100 p.p.b. in Chenal Ecarte.

Oils, greases, and other similar substances were observed in all parts of the river at different times. Other analytical results show less significant effects. The high average dissolved oxygen and low average B.O.D. results indicate that the oxygen balance is not materially disturbed by the discharges of oxygen consuming wastes. Objectionable conditions, however, are created in many local areas due to the presence of wastes.

Lake St. Clair

The intensity and distribution of pollution in Lake St. Clair are influenced by the division of flows through the St. Clair Flats, the direction of winds, the lake currents, the intermittent discharge of combined sewer overflows, and the action of natural purification agencies, although it is difficult to separate the influence of one factor from another.

Table 20 (see pages 93 to 105) is a summary of the analytical results for Lake St. Clair samples. The coliform results indicate the water to be of good quality in the lake except for localized areas. Highest median values were found at the outlet from Anchor Bay and at the mouths of the Chenal Ecarte and Thames River. Definite pollution paths are indicated by the coliform results.

The distribution of coliform concentrations is shown in figure 6 (follows page 92). It will be seen that, except at the mouths of the Chenal Ecarte and Thames River, the eastern portion of the lake is relatively free from pollution. The polluted waters from these two tributaries are lost within a distance of 1 to 2 miles into the lake. The main flow into the eastern section of the lake is through the South Channel. It carries 30 percent of the St. Clair River flow and comes from the less polluted middle section of the stream. The Chenal Ecarte and other tributaries on the Canadian side, carrying about 12.5 percent of the total St. Clair River flow, come from the more heavily polluted shore zone.

On the basis of the bacteriological results the bulk of the pollution entering Lake St. Clair is discharged into Anchor Bay and flows southward. There appears to be a definite line of demarcation between the pollution travelling from the North Channel and that from the Clinton River. The pollution coming from the North and Middle Channels moves as a mass or "front" and tends to flow south-southwest, becoming diffused and diluted as it moves into the lake. This front reaches the main ship channel (range I-IV-VI) about due east of Gaukler Point. In this area the pollution may follow one, or all, of three courses. A part of the front appears to split off and veer southeasterly into the larger portion of the lake on the Canadian side of the boundary. A portion seems to continue in a south by southwest direction into the Detroit River. A small portion probably splits away and veers off toward the United States shore below Gaukler Point.

The pollution from the Clinton River is apparently forced close to the west shore and follows the shore line south, around Point Huron and into the small bay to the west of Point Huron. From there the pollution tends to follow the shore line or to take a more direct course into the Detroit River.

Float studies and wind current data tend to confirm these possibilities of coliform distribution. The prevailing winds on days of sampling varied between a west-southwest and a south-southwest direction. The larger portion of the St. Clair River flow, amounting to 57.5 percent of the total, or an average of about 100,000 c.f.s., coming out of Anchor Bay in a front meets some resistance about due east of Gaukler Point and is dissipated in the west end of the lake. The winds coming from the southwest might form such resistance and might be in part responsible for the dissipation of this large flow. The winds blowing against the current would then cause a veering in different directions. Float studies in this area showed the existence of currents turning both clockwise and counter-clockwise from the flow in the ship channel.

A review of the results in table 20 reveals considerable variation between the median and maximum coliform values at the various sampling stations. Since the intensity and distribution of pollution at any one location are subjected to the many factors already mentioned these variations are not surprising. The median value is not necessarily indicative of these wide fluctuations. It is the peak or worse conditions which present a hazard to water purification plants and to bathing beaches.

Figure 7 (follows page 92) graphically portrays the distribution of the maximum coliform results in Lake St. Clair, as well as the average wind direction at each point on the date of the maximum occurrence. The chart indicates conditions which did occur, and which may be repeated. These conditions are especially significant in the western portion of the lake which serves as a source of water supply for Mt. Clemens, Highland Park, and Grosse Pointe Farms.

The maximum coliform results at the outlet from Anchor Bay further emphasize that there is a line of demarcation between the pollution from the Clinton River and that from the North Channel. The paths of travel above Gaukler Point are similar to those shown by the median values. Winds from the northeast or southeast quadrants caused high coliform concentrations along the United States shore from Anchor Bay to Gaukler Point. Under west-southwest winds the pollution hugged the United States shore between Gaukler Point and Windmill Point. Pollution coming through the North and Middle Channels seems to have a tendency to veer southeast across the ship channel and be dissipated in Canadian waters by winds from the southwest quadrant.

As would be expected, winds from the southwest and southeast quadrants caused high bacterial concentrations at the mouth of the Chenal Ecarte and other tributaries discharging along the north shore of the lake. Likewise, winds from the northwest and northeast quadrants built up concentrations at the mouths of the Thames and Belle Rivers, and along the south shore of the lake.

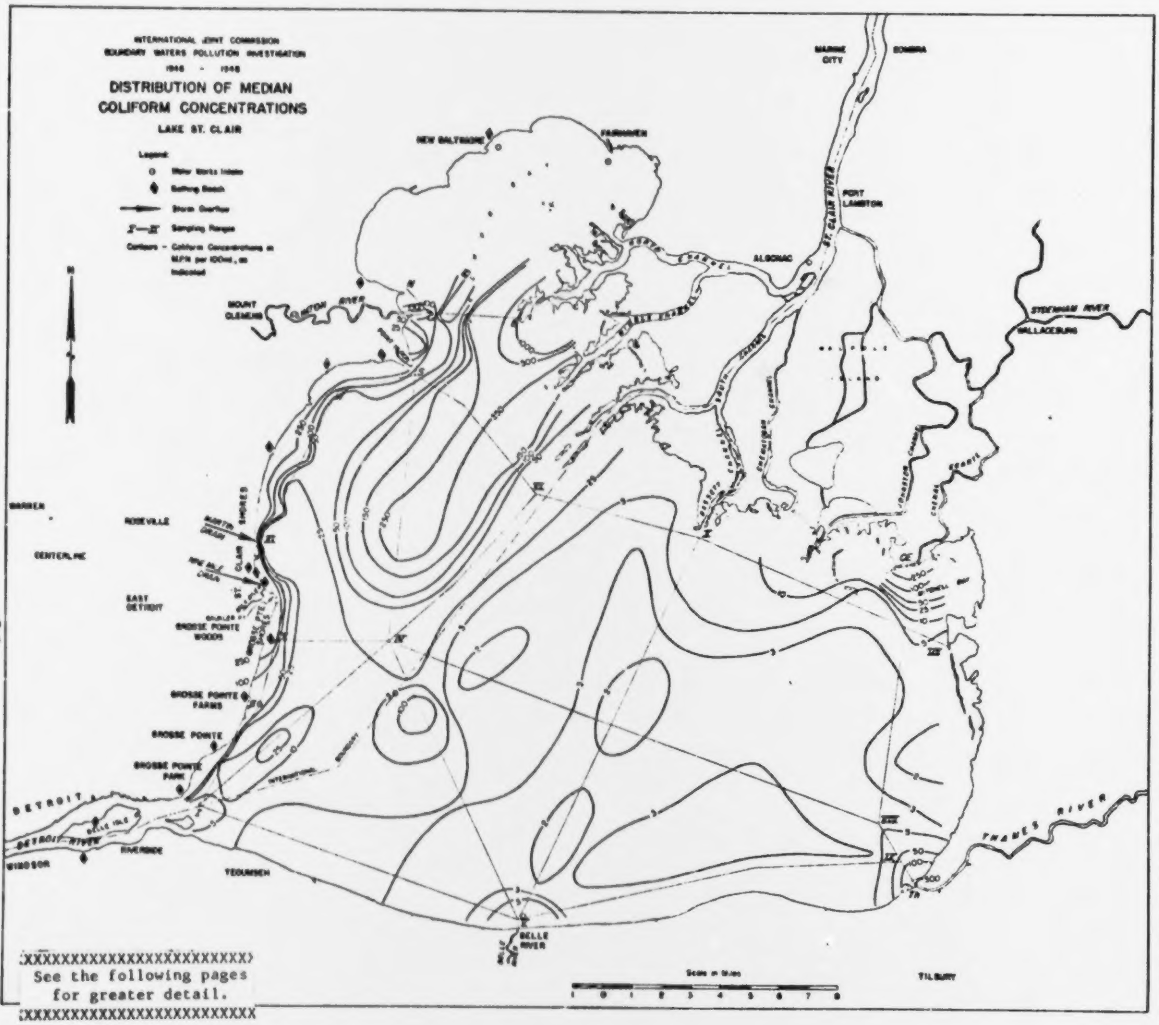
The locations of maximum M.P.N. coliform values are shown in table 20. At both the mouth of the Clinton River and at Point Huron the maximum values were 24,000 per 100 ml. From Point Huron to Windmill Point the maximum value was just under 5,000. These high concentrations can probably be attributed to the Clinton River discharge and to the various combined sewer overflows from Macomb and Wayne Counties, especially Nine Mile and Martin Drains. On the Canadian side, the highest M.P.N. value was 11,000 and was found at the mouth of the Thames River. The next highest value, 2,400 per 100 ml., was at the mouth of the Chenal Ecarte.

Maximum and average phenol results are presented in figure 8 (follows page 92). Average values are generally below 10 p.p.b. Results on range Cl-E, across the mouth of Anchor Bay, again show a line of demarcation between the flow coming from the St. Clair River and that coming from the Clinton River. Averages varied from 8.2 p.p.b. at the mouth of the Clinton River to 2.7 at the middle of the range and up to 12 p.p.b. at the mouth of the North Channel. As would be expected, the behavior of phenol distribution in the lake followed a pattern similar to that for coliforms, since both are carried by the same water vehicle.

Analytical results for samples taken in Canadian waters showed very low average phenol concentrations. Highest values were found in the vicinity of Bassett Channel, and along the south shore of the lake near the mouths of the Thames and Belle Rivers. Maximum phenol values in the Candian waters are generally lower than those found in the United States waters.

Oxygen results do not indicate any noticeable depletion in the lake waters. The dissolved oxygen content averaged 8 to 10 p.p.m. while minimum values were, in practically all instances, over 6 or 7 p.m. Biochemical oxygen demand generally averaged less than 1 p.p.m., with maximum values of up to 3 p.p.m.

Turbidity results were highest in the United


INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948
DISTRIBUTION OF MEDIAN
COLIFORM CONCENTRATIONS
LAKE ST. CLAIR
Legend
Water Works Intake
Bathing Beach
Storm Overflow
I—II Sampling Ranges
Contours - Coliform Concentrations in M.P.N per 100ml, as Indicated
N
NEW BALTIMORE
FAIRHAVEN
MARINE CITY
SOMBRA
PORT LAMBTON
ST. CLAIR RIVER
ALGONAC
NORTH CHANNEL
MIDDLE CHANNEL
SOUTH CHANNEL
SYDENHAM RIVER
WALLACEBURG
MOUNT CLEMENS
CLINTON RIVER
WARREN
ROSEVILLE
CENTERLINE
EAST DETROIT
ST. CLAIR SHORES
GROSSE POINTE WOODS
GROSSE POINTE FARMS
GROSSE POINTE
GROSSE POINTE PARK
INTERNATIONAL BOUNDARY
DETROIT RIVER
BELLE ISLE
WINDSOR
RIVERSIDE
TECUMSEH
BELLE RIVER
THAMES RIVER
TILBURY
Scale in Miles
1 0 1 2 3 4 5 6 7 8
250
150
100
50
25
10
5
500

XXXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXXX

Figure 6

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948

DISTRIBUTION OF MEDIAN COLIFORM CONCENTRATIONS

LAKE ST. CLAIR

Legend:
- ○ Water Works Intake
- ◆ Bathing Beach
- → Storm Overflow
- I—II Sampling Ranges
- Contours - Coliform Concentrations in M.P.N. per 100ml, as Indicated

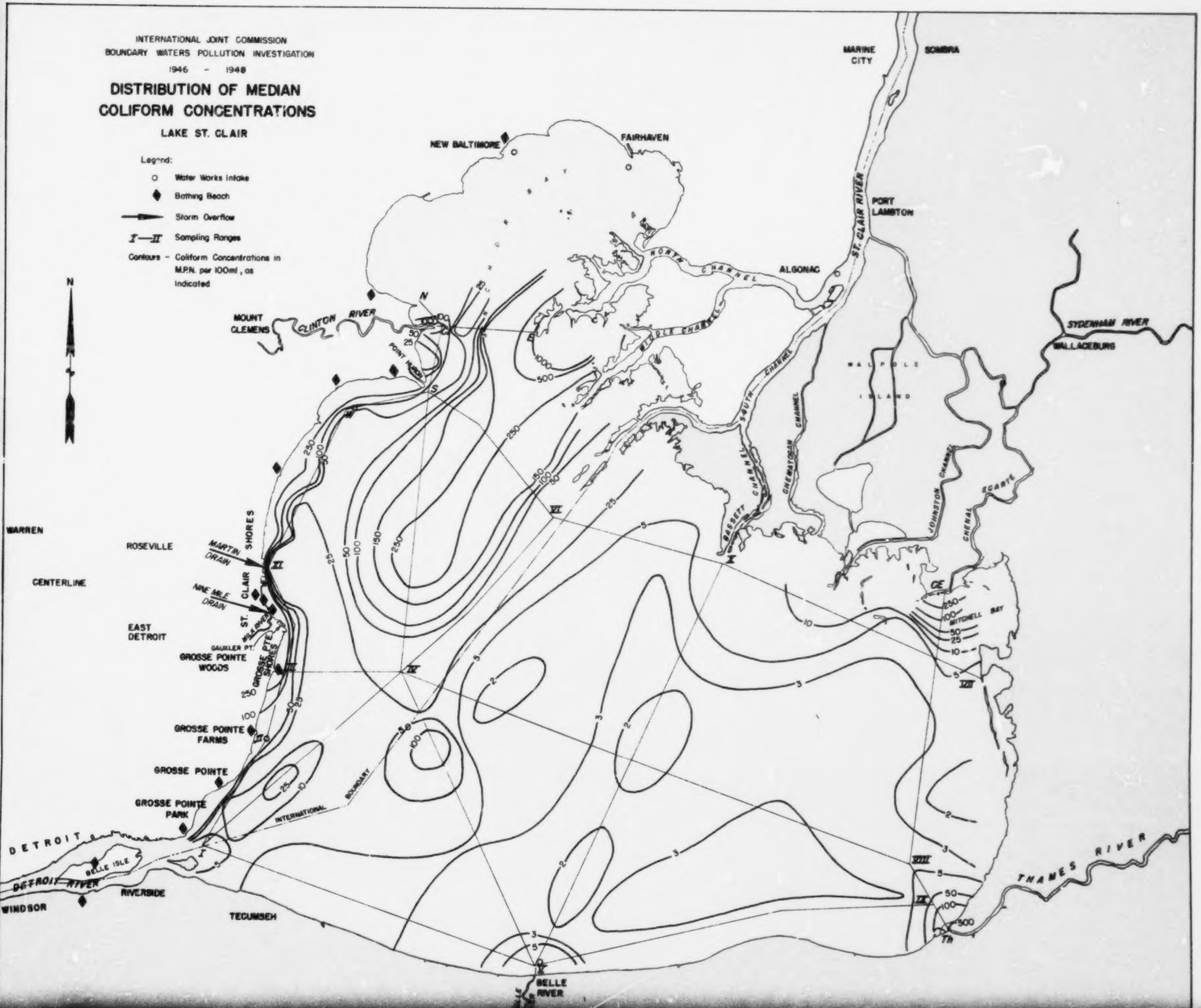

N
MARINE CITY
SOMBRA
NEW BALTIMORE
FAIRHAVEN
PORT LAMBTON
ST. CLAIR RIVER
ALGONAC
NORTH CHANNEL
MIDDLE CHANNEL
SOUTH CHANNEL
BASSETT CHANNEL
CHENAYOGAN CHANNEL
WALPOLE ISLAND
JOHNSTON CHANNEL
CHENAL ECARTE
SYDENHAM RIVER
WALLACEBURG
MOUNT CLEMENS
CLINTON RIVER
POINT HURON
WARREN
ROSEVILLE
CENTERLINE
EAST DETROIT
MARTIN DRAIN
NINE MILE DRAIN
ST. CLAIR SHORES
GAUKLER PT.
GROSSE POINTE WOODS
GROSSE PTE. SHORES
GROSSE POINTE FARMS
GROSSE POINTE
GROSSE POINTE PARK
INTERNATIONAL BOUNDARY
DETROIT
BELLE ISLE
DETROIT RIVER
RIVERSIDE
WINDSOR
TECUMSEH
BELLE RIVER
MITCHELL BAY
THAMES RIVER
I
II
III
IV
V
VI
VII
VIII
IX
1000
500
250
150
100
50
25
10
5
3
2

Figure 6

99

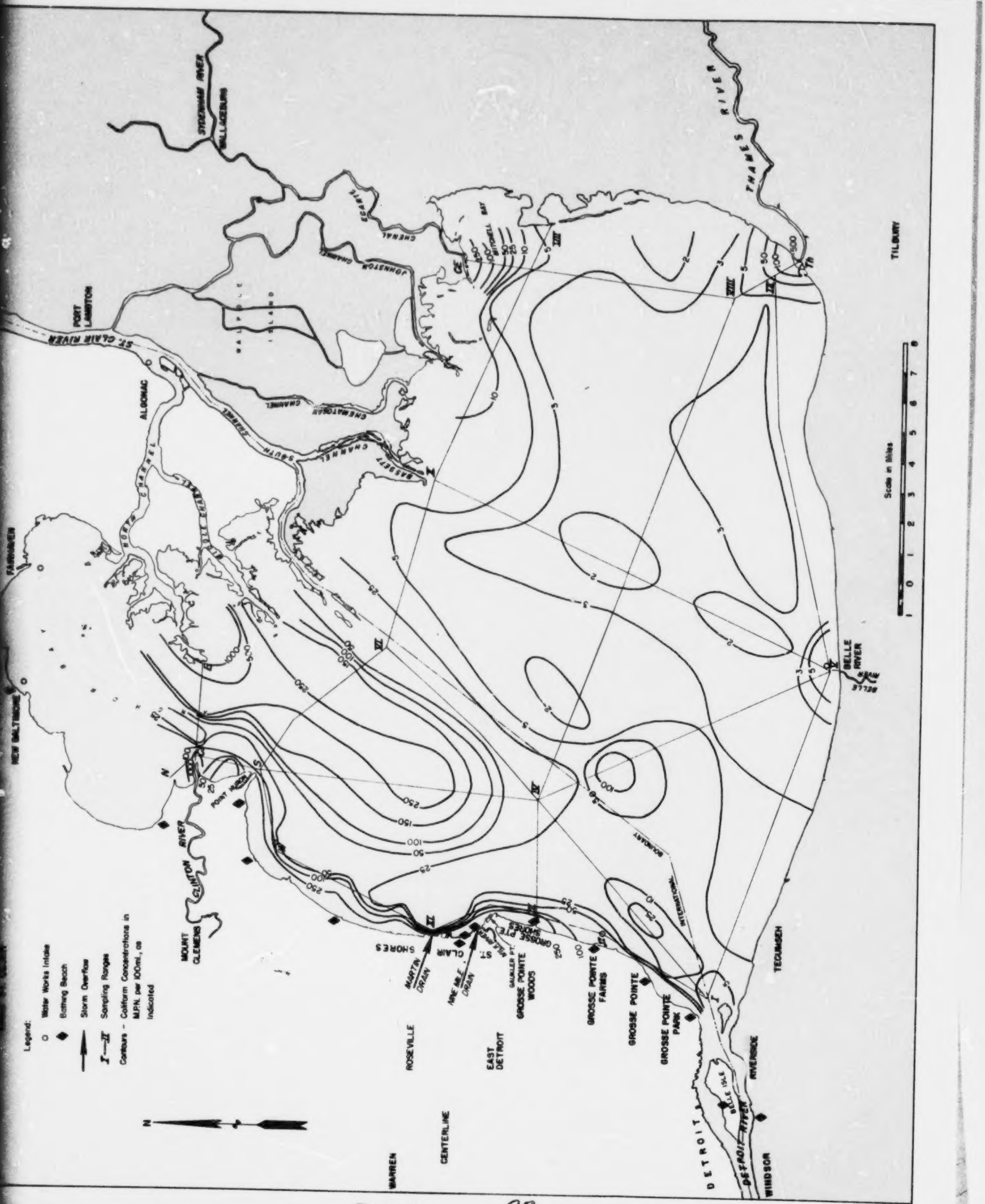
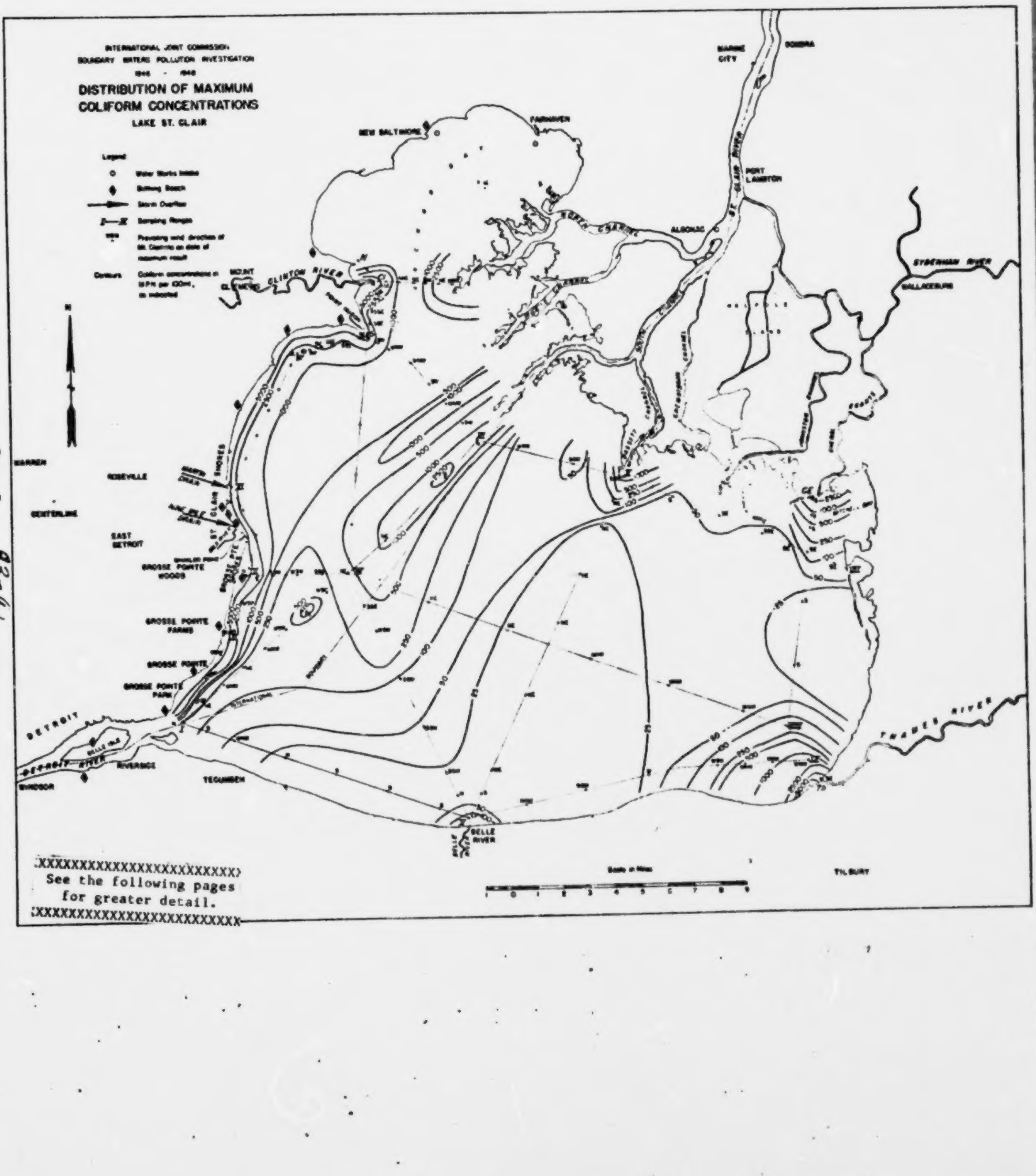

Legend:
Water Works Intake
Bathing Beach
Storm Overflow
Sampling Ranges
Contours - Coliform Concentrations in M.P.N. per 100ml, as Indicated
Scale in Miles
WARREN
CENTERLINE
ROSEVILLE
EAST DETROIT
DETROIT
WINDSOR
RIVERSIDE
TECUMSEH
TILBURY
BELLE RIVER
MOUNT CLEMENS
CLINTON RIVER
POINT HURON
NEW BALTIMORE
FAIRHAVEN
ALGONAC
PORT LAMBTON
ST. CLAIR RIVER
WALLACEBURG
SYDENHAM RIVER
THAMES RIVER
WALPOLE ISLAND
JOHNSTON CHANNEL
CHENAL ECARTE
CHEMATOGAN CHANNEL
BASSETT CHANNEL
SOUTH CHANNEL
NORTH CHANNEL
MITCHELL BAY
GROSSE POINTE
GROSSE POINTE PARK
GROSSE POINTE FARMS
GROSSE POINTE WOODS
GROSSE PTE. SHORES
ST. CLAIR SHORES
MARTIN DRAIN
NINE MILE DRAIN
BELLE ISLE
DETROIT RIVER
INTERNATIONAL BOUNDARY

Figure 6

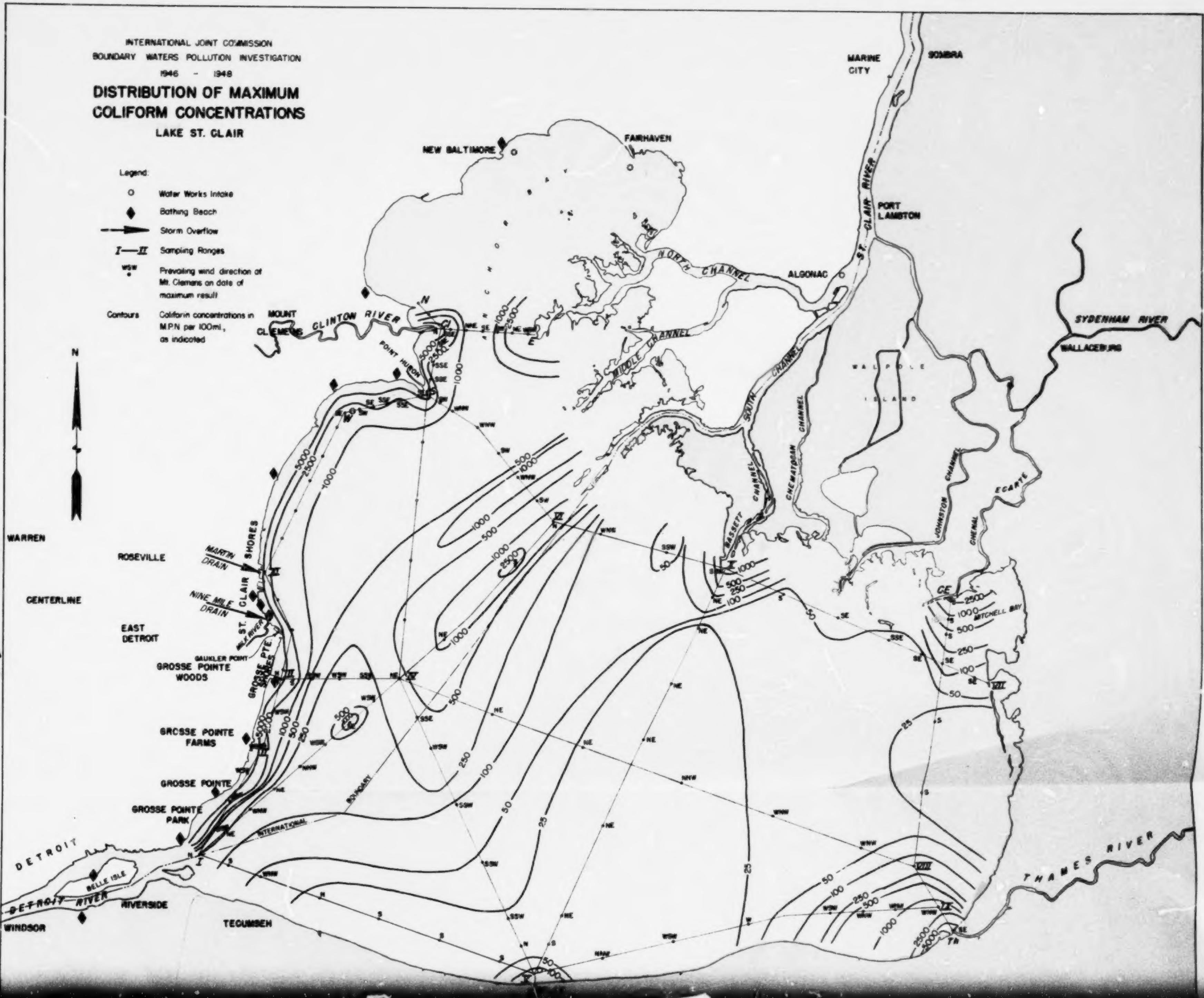
92


INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948
DISTRIBUTION OF MAXIMUM COLIFORM CONCENTRATIONS
LAKE ST. CLAIR
Legend
Water Works Intake
Bathing Beach
Storm Overflow
Sampling Ranges
Prevailing wind direction at Mt. Clemens on date of maximum result
Contours
Coliform concentrations in MPN per 100ml, as indicated
N
NEW BALTIMORE
FAIRHAVEN
MARINE CITY
SOMBRA
PORT LAMBTON
ALGONAC
ST. CLAIR RIVER
NORTH CHANNEL
SYDENHAM RIVER
WALLACEBURG
MOUNT CLEMENS
CLINTON RIVER
WARREN
ROSEVILLE
CENTERLINE
EAST DETROIT
ST. CLAIR SHORES
GROSSE POINTE WOODS
GROSSE POINTE FARMS
GROSSE POINTE
GROSSE POINTE PARK
DETROIT
DETROIT RIVER
BELLE ISLE
WINDSOR
RIVERSIDE
TECUMSEH
BELLE RIVER
THAMES RIVER
TILBURY
Scale in Miles
1 0 1 2 3 4 5 6 7 8 9

XXXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXXX

Figure 7

93-a



Legend:
○ Water Works Intake
◆ Bathing Beach
Storm Overflow
I—II Sampling Ranges
WSW Prevailing wind direction at Mt. Clemens on date of maximum result
Contours Coliform concentrations in M.P.N. per 100ml, as indicated
N
NEW BALTIMORE
FAIRHAVEN
MARINE CITY
SOMBRA
PORT LAMBTON
ST. CLAIR RIVER
ALGONAC
NORTH CHANNEL
MIDDLE CHANNEL
SOUTH CHANNEL
CHENAL
CHEMATOGAN CHANNEL
WALPOLE ISLAND
JOHNSTON CHANNEL
CHENAL ECARTE
SYDENHAM RIVER
WALLACEBURG
BASSETT CHANNEL
MITCHELL BAY
THAMES RIVER
MOUNT CLEMENS
CLINTON RIVER
POINT HURON
WARREN
ROSEVILLE
CENTERLINE
EAST DETROIT
ST. CLAIR SHORES
MARTIN DRAIN
NINE MILE DRAIN
MILK RIVER
GAUKLER POINT
GROSSE POINTE WOODS
GROSSE PTE SHORES
GROSSE POINTE FARMS
GROSSE POINTE
GROSSE POINTE PARK
INTERNATIONAL BOUNDARY
DETROIT
BELLE ISLE
DETROIT RIVER
RIVERSIDE
WINDSOR
TECUMSEH
5000
2500
1000
500
250
100
50
25

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948

DISTRIBUTION OF MAXIMUM COLIFORM CONCENTRATIONS

LAKE ST. CLAIR

Figure 7

93-a

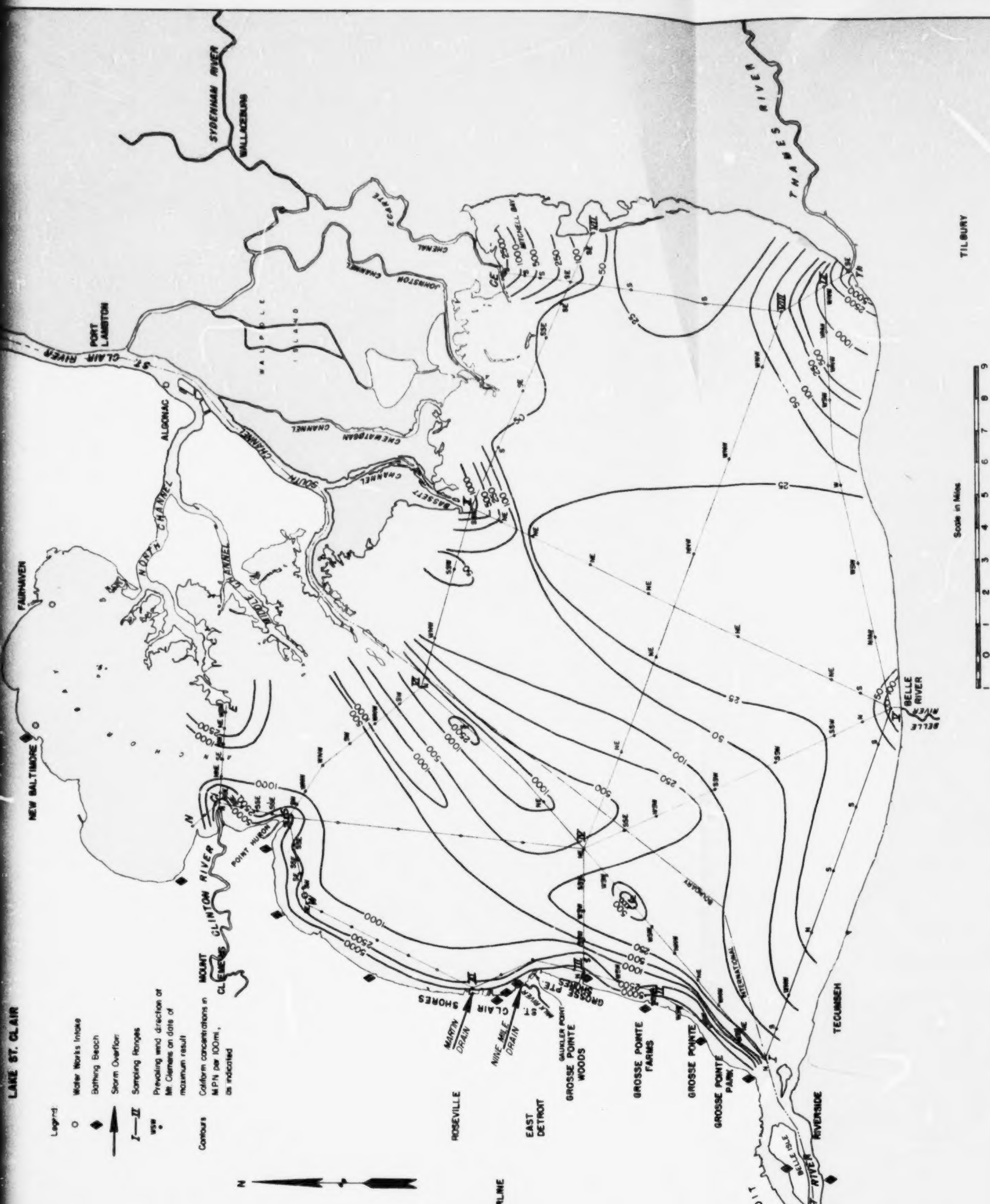
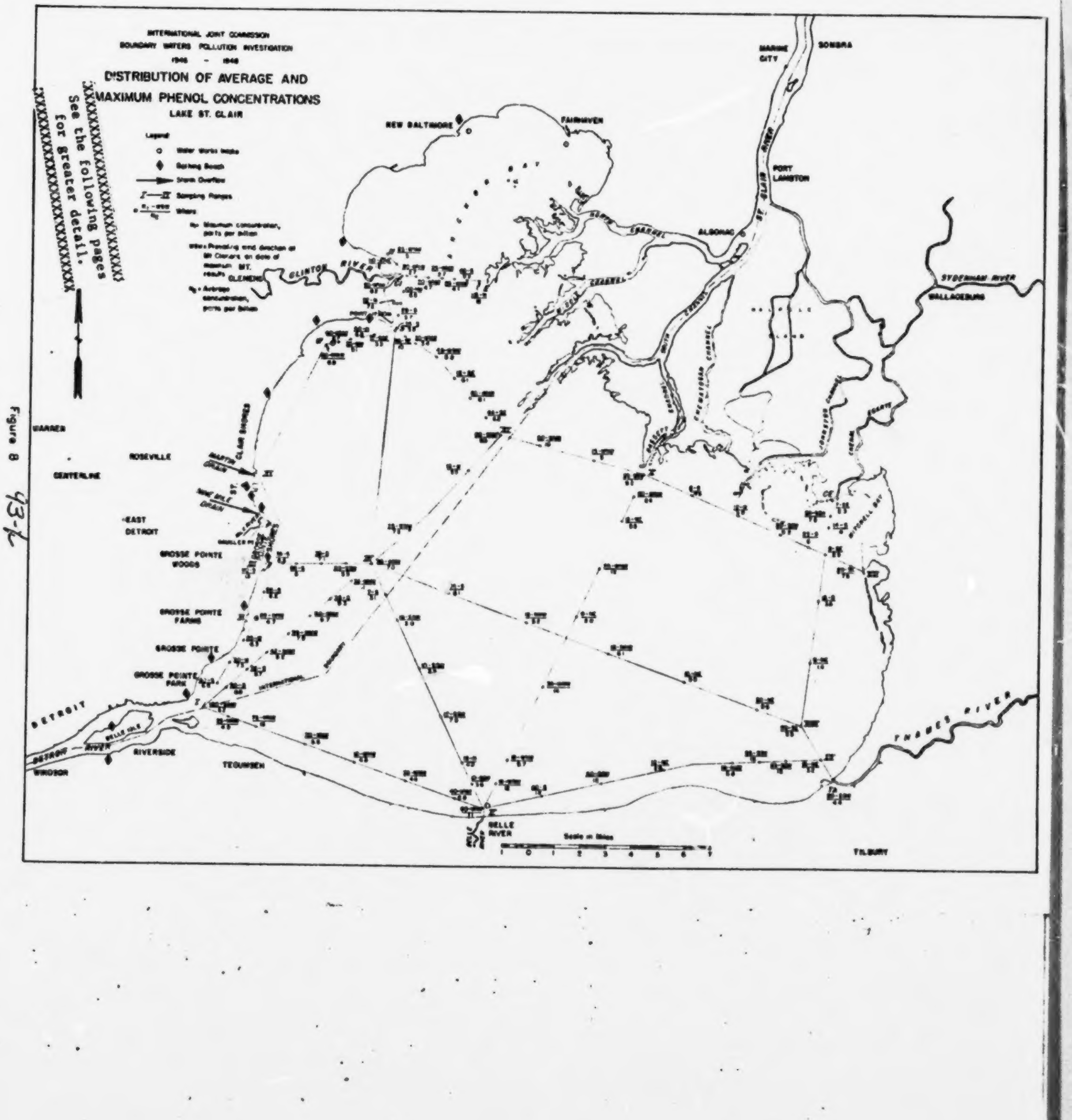

LAKE ST. CLAIR
Legend
Water Works Intake
Bathing Beach
Storm Overflow
Sampling Ranges
Prevailing wind direction at Mt. Clemens on date of maximum result
Contours
Coliform concentrations in MPN per 100ml, as indicated
N
Scale in Miles
WARREN
ROSEVILLE
CENTERLINE
EAST DETROIT
GROSSE POINTE WOODS
GROSSE POINTE FARMS
GROSSE POINTE
GROSSE POINTE PARK
DETROIT
DETROIT RIVER
BELLE ISLE
WINDSOR
RIVERSIDE
TECUMSEH
BELLE RIVER
TILBURY
THAMES RIVER
MOUNT CLEMENS
CLINTON RIVER
POINT HURON
ST. CLAIR SHORES
MARTIN DRAIN
NINE MILE DRAIN
GROSSE PTE. SHORES
NEW BALTIMORE
FAIRHAVEN
ALGONAC
NORTH CHANNEL
MIDDLE CHANNEL
SOUTH CHANNEL
BASSETT CHANNEL
CHENAL ECARTE
CHEWATBAN CHANNEL
JOHNSTON CHANNEL
WALPOLE ISLAND
ST. CLAIR RIVER
PORT LAMBTON
WALLACEBURG
SYDENHAM RIVER
MITCHELL BAY
INTERNATIONAL BOUNDARY
5000
2500
1000
500
250
100
50
25

Figure 7

93-a



INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948
DISTRIBUTION OF AVERAGE AND MAXIMUM PHENOL CONCENTRATIONS
LAKE ST. CLAIR
Legend
Water Works Intake
Bathing Beach
Storm Overflow
I—II Sampling Ranges
Values
Maximum concentration, parts per billion
Prevailing wind direction at Mt Clemens on date of maximum
Average concentration, parts per billion
MARINE CITY
SOMBRA
NEW BALTIMORE
FAIRHAVEN
PORT LAMBTON
ALGONAC
ST. CLAIR RIVER
CLINTON RIVER
MT. CLEMENS
SYDENHAM RIVER
WALLACEBURG
WARREN
ROSEVILLE
CENTERLINE
EAST DETROIT
GROSSE POINTE WOODS
GROSSE POINTE FARMS
GROSSE POINTE
GROSSE POINTE PARK
DETROIT
DETROIT RIVER
BELLE ISLE
WINDSOR
RIVERSIDE
TECUMSEH
BELLE RIVER
THAMES RIVER
TILBURY
Scale in Miles
1 0 1 2 3 4 5 6 7

See the following pages for greater detail.

Figure 8

43-k

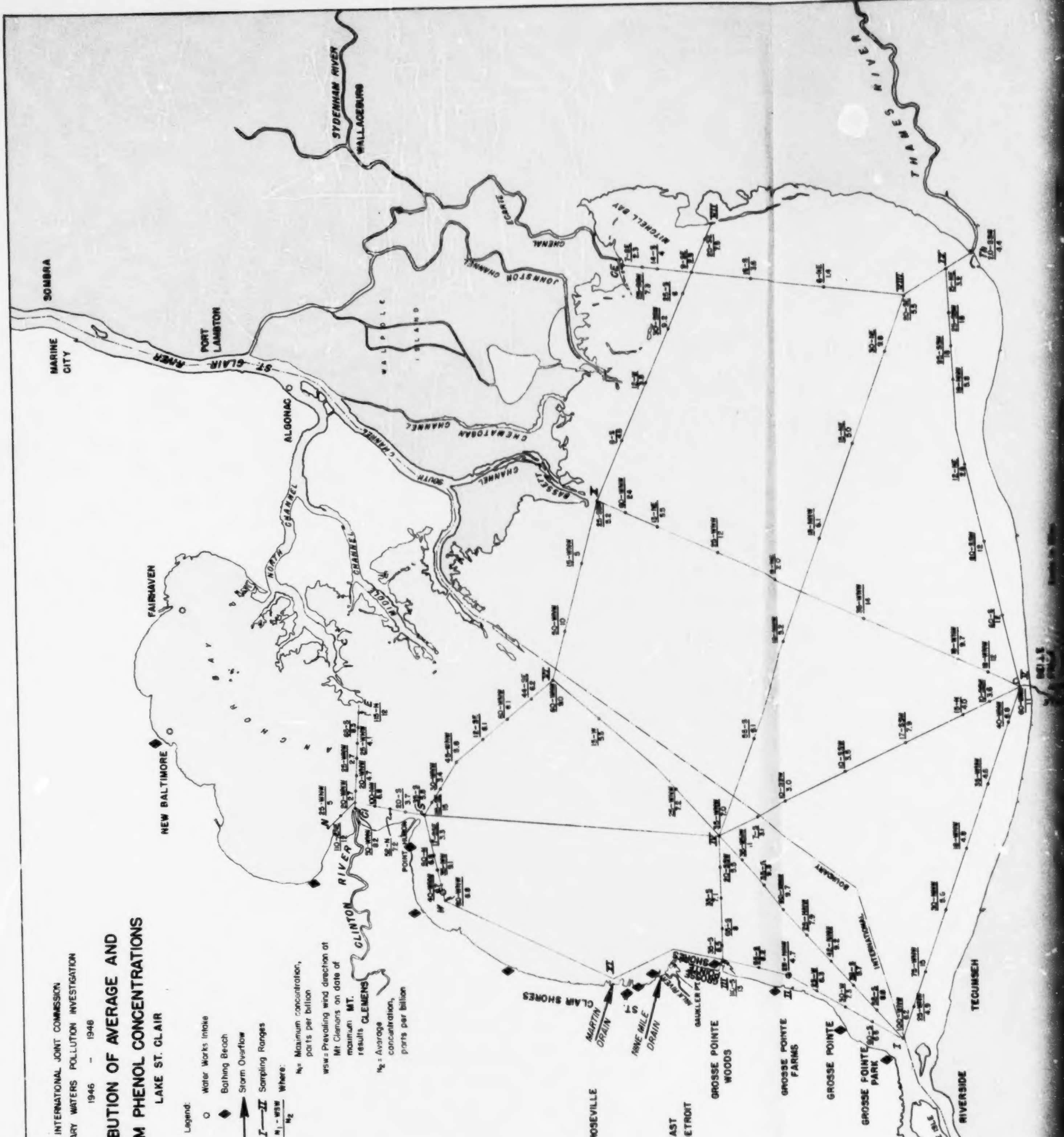
INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948
DISTRIBUTION OF AVERAGE AND
MAXIMUM PHENOL CONCENTRATIONS
LAKE ST. CLAIR
Legend:
○ Water Works Intake
◆ Bathing Beach
→ Storm Overflow
I—II Sampling Ranges
• N1-WSW/N2 Where:
N1 = Maximum concentration, parts per billion
WSW = Prevailing wind direction at Mt Clemens on date of maximum results
N2 = Average concentration, parts per billion
N
WARREN
CENTERLINE
ROSEVILLE
EAST DETROIT
GROSSE POINTE WOODS
GROSSE POINTE FARMS
GROSSE POINTE
GROSSE POINTE PARK
DETROIT
DETROIT RIVER
BELLE ISLE
WINDSOR
RIVERSIDE
TECUMSEH
CLAIR SHORES
ST.
MARTIN DRAIN
NINE MILE DRAIN
GAULKER PT.
GROSSE POINTE SHORES
MT. CLEMENS
CLINTON RIVER
NEW BALTIMORE
ANCHOR BAY
FAIRHAVEN
NORTH CHANNEL
MIDDLE CHANNEL
SOUTH CHANNEL
BASSETT CHANNEL
CHENAL ECARTE
ALGONAC
MARINE CITY
ST. CLAIR RIVER
PORT LAMBTON
SOMBRA
CHEMATOGAN CHANNEL
WALPOLE ISLAND
JOHNSTON CHANNEL
MITCHELL BAY
WALLACEBURG
SYDENHAM RIVER
THAMES RIVER
INTERNATIONAL BOUNDARY
I
II
III
IV
V
VI
VII
VIII

Figure 8 93-6

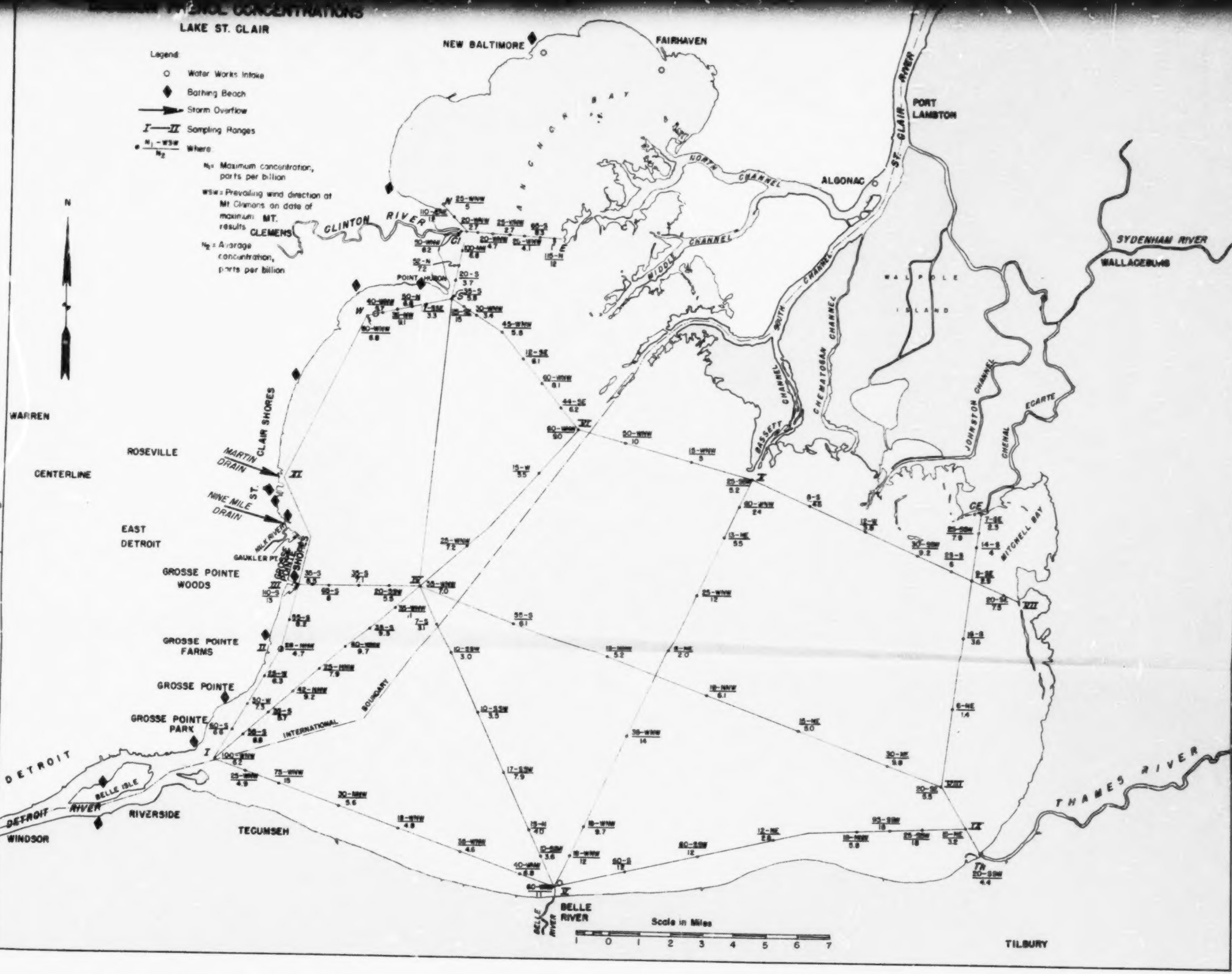

PHENOL CONCENTRATIONS
LAKE ST. CLAIR
Legend
○ Water Works Intake
◆ Bathing Beach
Storm Overflow
I——II Sampling Ranges
• N1 - WSW / N2 Where
N1 = Maximum concentration, parts per billion
WSW = Prevailing wind direction at Mt Clemens on date of maximum results
N2 = Average concentration, parts per billion
N
NEW BALTIMORE
FAIRHAVEN
ANCHOR BAY
NORTH CHANNEL
MIDDLE CHANNEL
ALGONAC
ST. CLAIR RIVER
PORT LAMBTON
SOUTH CHANNEL
CHENATOGAN CHANNEL
BASSETT CHANNEL
WALPOLE ISLAND
JOHNSTON CHANNEL
CHENAL ECARTE
SYDENHAM RIVER
WALLACEBURG
MITCHELL BAY
MT. CLEMENS
CLINTON RIVER
POINT HURON
ST. CLAIR SHORES
MARTIN DRAIN
NINE MILE DRAIN
MILK RIVER
GAUKLER PT.
GROSSE POINTE SHORES
WARREN
ROSEVILLE
CENTERLINE
EAST DETROIT
GROSSE POINTE WOODS
GROSSE POINTE FARMS
GROSSE POINTE
GROSSE POINTE PARK
INTERNATIONAL BOUNDARY
DETROIT
BELLE ISLE
DETROIT RIVER
RIVERSIDE
WINDSOR
TECUMSEH
BELLE RIVER
THAMES RIVER
TILBURY
Scale in Miles
1 0 1 2 3 4 5 6 7

Figure 8

93-h

TABLE 20—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ST. CLAIR

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold: Raw No.	Threshold Odor, Cold: Raw Nature	Threshold Odor, Cold: Chlorinated No.	Threshold Odor, Cold: Chlorinated Nature	Taste	Total Solids ppm: Total	Total Solids ppm: Volatile
I—II—III West Shore, Windmill Pte. to Grosse Pte Shores	0.0(I)	Median	9.1																
		Average		6.8	6.2	.003	.27	17.0	9.65	.26	12							156	88
		Maximum	43	11.0	100	.46	.35	25	11.4	.90	44							200	108
		Minimum	<1.8	4.7	0	0	.15	11.0	8.6	0	5							114	68
		No. of Samples	24	23	24	20	3	19	24	24	21						6	3	3
	1.0	Median	9.1																
		Average		8.1	6.6	0.015	0.18	16.0	10.0	0.43	11							155	82
		Maximum	2400	12.0	60	0.10	0.2	22.5	10.9	0.80	20							168	88
		Minimum	3.6	4.4	0	0	0.15	11.0	8.8	0.20	5							142	76
		No. of Samples	13	13	13	11	2	11	13	13	11						3	2	2
	2.0	Median	23																
		Average		8.1	7.3	0.02	0.25	16.5	9.9	0.64	11							157	82
		Maximum	430	12.0	30	0.14	0.30	22.5	10.7	1.8	20							158	82
		Minimum	2	5.2	0	0	0.20	11.0	8.5	0.23	5							156	82
		No. of Samples	13	13	13	11	2	11	13	13	11						3	2	2
	3.0	Median	23																
		Average		7.8	6.3	0.016	0.23	16.5	9.8	0.68	12							158	88
		Maximum	4,300	9.7	25	0.12	0.25	23.0	10.8	3.0	30							158	95
		Minimum	<1.8	4.4	0	0	0.20	11.0	8.4	0	6							158	82
		No. of Samples	13	13	13	11	2	11	13	13	11						3	2	2
	4.0(II)	Median	84																
		Average		7.8	4.7	0.006	0.23	17.0	9.85	0.95	11							159	82
		Maximum	4,600	11.0	28	0.04	0.25	22.5	10.8	4.0	24							160	82
		Minimum	<1.8	5.5	0	0	0.20	11.0	8.3	0.35	6							158	82
		No of Samples	12	12	12	10	2	10	12	12	10						3	2	2
	5.0	Median	93																
		Average		7.85	8.2	0.014	0.23	17.5	9.9	0.84	9							164	84
		Maximum	1,500	12.0	55	0.08	0.30	22.5	10.8	2.6	13							172	88
		Minimum	<2.3	5.5	0	0	0.15	11.0	8.4	0.34	6							156	82
		No. of Samples	13	13	13	11	2	11	13	13	5						3	2	2
	6.0(III)	Median	350																
		Average		8.1	13	0.0178	0.20	16.5	9.9	1.23	12							174	94
		Maximum	4,600	10.5	110	0.14	0.20	22.5	11.8	6.6	6							180	96
		Minimum	9.1	5.2	0	0	0.20	11.0	8.0	0.23	30							168	92
		No. of Samples	13	14	14	12	2	12	14	14	12						3	2	2
	6.0			For Point III, Refer to Range I—II—III															
III—XI Grosse Pte. Yacht Club to St. Clair Shores Light Buoy	6.5	Median	210																
		Average		7.8	0	0.0013		12.2	10.2	0.65	26								
		Maximum	>2,400	8.5	0	0.004		13.0	10.8	1.0	42								
		Minimum	43	7.2	0	0		11.0	9.9	0.41	19								
		No. of Samples	3	3	3	3		3	3	3	3								

TABLE 20—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ST. CLAIR—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
III—XI (Continued) Grosse Pte. Yacht Club to St. Clair Shores Light Buoy	7.5	Median	93																
		Average	...	7.1	0	0	...	12.2	10.1	0.51	22	...	...	...	...	...	...	...	...
		Maximum	150	8.0	0	0	...	13.0	10.5	0.68	38	...	...	...	...	...	...	...	...
		Minimum	75	6.4	0	0	...	11.0	9.9	0.36	11	...	...	...	...	...	...	...	...
		No. of Samples	3	3	3	3	...	3	3	3	3	...	...	...	...	...	...	...	...
	8.5	Median	23																
		Average	...	6.3	0	0	...	12.2	10.1	0.303	13	...	...	...	...	...	...	...	...
		Maximum	43	7.0	0	0	...	13.0	10.6	0.48	16	...	...	...	...	...	...	...	...
		Minimum	9.1	6.0	0	0	...	11.0	9.7	0.19	18	...	...	...	...	...	...	...	...
		No. of Samples	3	3	3	3	...	3	3	3	3	...	...	...	...	...	...	...	...
	0.0(III)																		
III—IV—VIII Grosse Pte. Yacht Club to Buoy 23 to outer Thames Buoy	0.5	Median	23																
		Average	...	7.8	8.5	0.009	0.25	15.4	9.9	0.87	9	...	...	...	...	...	...	157	82
		Maximum	4,600	8.2	35	0.04	0.30	22.5	11.8	2.6	16	...	...	...	...	...	...	166	84
		Minimum	<1.8	4.5	0	0	0.20	12.5	8.4	0.14	5	...	...	...	...	...	...	148	80
		No. of Samples	11	11	11	9	2	9	11	11	9	...	...	...	...	...	3	2	2
	1.0	Median	43																
		Average	...	8.1	8	0.006	0.75	14.8	10	0.79	7	...	...	...	...	...	...	150	79
		Maximum	460	11.0	65	0.04	1.3	23.0	10.8	3.0	16	...	...	...	...	...	...	156	82
		Minimum	3.6	4.8	0	0.01	0.20	12.0	8.7	0.33	4	...	...	...	...	...	...	144	76
		No. of Samples	11	11	11	9	2	9	11	11	8	...	...	...	...	...	3	2	2
	2.0	Median	23																
		Average	...	7.9	7.1	0.009	0.20	16.5	10.1	0.63	7	...	...	...	...	...	...	151	76
		Maximum	93	11.3	35	0.06	0.30	22.0	11.2	2.0	12	...	...	...	...	...	...	156	70
		Minimum	<1.8	5.1	0	0	0.10	11.0	8.7	0.21	5	...	...	...	...	...	...	146	82
		No. of Samples	11	11	11	9	2	9	11	11	9	...	...	...	...	...	...	2	2
	3.0	Median	43																
		Average	...	7.7	5.5	0.002	0.18	16.5	10.3	1.07	7	...	...	...	...	...	...	157	88
		Maximum	240	10.2	20	0.01	0.25	22.0	11.2	6.8	9	...	...	...	...	...	...	160	96
		Minimum	<1.8	4.9	0	0	0.10	11.0	8.6	0.18	6	...	...	...	...	...	...	154	80
		No. of Samples	11	11	11	9	2	9	11	11	9	...	...	...	...	...	3	2	2
	4.0(IV)	Median	46																
		Average	...	7.2	7.0	0.003	0.20	17.5	10.0	0.49	9	...	...	...	...	...	...	141	80
		Maximum	460	11.0	35	0.06	0.25	23.5	8.6	4.0	23	...	...	...	...	...	...	158	90
		Minimum	<1.8	4.1	0	0	0.15	11.0	11.4	0	5	...	...	...	...	...	...	112	72
		No. of Samples	26	26	26	23	3	20	26	26	24	...	...	...	...	...	8	3	3
	7.0	Median	9.1																
		Average	...	8.0	13.8	0.0016	0.18	20.0	9.8	0.84	7	...	...	...	...	...	...	153	84
		Maximum	150	11.5	55	0.01	0.25	23.5	11.0	2.4	9	...	...	...	...	...	...	154	88
		Minimum	<1.8	6.3	0	0	0.10	14.0	8.6	0.33	4	...	...	...	...	...	...	152	80
		No. of Samples	8	8	8	6	2	5	8	8	8	...	...	...	...	...	3	2	2

	10.0	Median	3.6																
		Average	...	6.9	5.2	0.007	0.23	20.9	9.5	0.41	10	...	...	...	...	...	...	...	...
		Maximum	15	8.4	15	0.04	0.30	24.5	10.4	0.66	33	...	...	...	...	...	...	...	...
		Minimum	2	6.1	0	0	0.15	15.5	8.4	0	4	...	...	...	...	...	...	...	...
		No. of Samples	7	8	8	6	2	5	8	8	8	...	...	...	...	...	3	...	...
	13.0	Median	2.3																
		Average	...	6.8	6.1	0.015	0.33	22.0	8.9	6.1	19	...	...	...	...	...	...	174	118
		Maximum	3.6	8.4	18	0.04	0.50	25.0	9.4	1.0	49	...	...	...	...	...	...	208	124
		Minimum	<1.8	5.3	0	0	0.15	18.0	8.0	0.14	4	...	...	...	...	...	...	180	112
		No. of Samples	8	8	8	6	2	5	8	8	8	...	...	...	...	...	3	2	2
	16.0	Median	3.6																
		Average	...	5.7	5.0	0.018	0.35	22.5	8.9	0.85	17	...	...	...	...	...	...	192	111
		Maximum	30	7.1	15	0.06	0.50	25.5	9.4	1.3	50	...	...	...	...	...	...	200	120
		Minimum	<1.8	1.2	0	0	0.20	18.5	8.3	0.08	3	...	...	...	...	...	...	184	102
		No. of Samples	8	8	8	6	2	5	8	8	8	...	...	...	...	...	3	2	2
	19.0	Median	2.3																
		Average	...	6.8	9.75	0.018	0.20	22.5	8.9	0.88	13	...	...	...	...	...	...	193	103
		Maximum	43	8.9	30	0.05	0.20	26.0	9.4	2.8	47	...	...	...	...	...	...	196	104
		Minimum	<1.8	5.0	0	0	0.20	18.5	8.2	0.16	5	...	...	...	...	...	...	190	102
		No. of Samples	8	8	8	6	2	5	8	8	8	...	...	...	...	...	3	2	2
	21.0(VIII)			For Point VIII, Refer to Range Th—IX—VIII—CE															
	0.0(I)			For Point I, Refer to Range I—II—III															
I—IV—VI Ship Channel, Windmill Pte. to St. Clair Flats	1.0	Median	19																
		Average	...	6.8	8.8	0.001	0.20	18.0	9.8	0.58	8	...	...	...	...	...	...	...	...
		Maximum	240	9.0	55	0.01	0.20	22.5	11.4	2.6	13	...	...	...	...	...	...	...	...
		Minimum	3.6	5.1	0	0	0.20	11.0	8.7	0.15	6	...	...	...	...	...	...	152	92
		No. of Samples	12	12	13	11	1	10	13	13	10	...	...	...	...	...	4	1	1
	2.0	Median	23																
		Average	...	7.2	5.7	0.023	0.23	18.0	9.9	5.2	9	...	...	...	...	...	...	144	83
		Maximum	93	8.6	35	0.16	0.25	22.0	11.4	2.4	14	...	...	...	...	...	...	128	72
		Minimum	2	5.4	0	0	0.20	11.5	8.8	0	5	...	...	...	...	...	...	160	94
		No. of Samples	13	13	13	11	2	10	13	13	11	...	...	...	...	...	4	2	2
	3.0	Median	43																
		Average	...	7.3	9.2	0.032	0.23	18.5	9.9	0.57	9	...	...	...	...	...	...	135	80
		Maximum	150	8.9	42	0.32	0.25	22.0	10.8	1.8	21	...	...	...	...	...	...	150	90
		Minimum	2	5.4	0	0	0.20	12.0	8.7	0.23	4	...	...	...	...	...	...	120	70
		No. of Samples	13	13	13	11	2	10	13	13	11	...	...	...	...	...	4	2	2
	4.0	Median	23																
		Average	...	6.9	7.9	0.032	0.23	18.0	9.8	0.42	9	...	...	...	...	...	...	140	...
		Maximum	93	8.4	25	0.18	0.25	22.0	11.0	1.0	13	...	...	...	...	...	...	154	...
		Minimum	1.8	5.6	0	0	0.20	12.0	8.7	0.20	5	...	...	...	...	...	...	126	76
		No. of Samples	13	13	13	11	2	10	13	13	11	...	...	...	...	...	4	2	1
	5.0	Median	9.1																
		Average	...	7.3	9.7	0.028	0.25	18.0	9.9	5.9	8	...	...	...	...	...	...	152	84
		Maximum	150	8.7	60	0.24	0.30	22.5	12.8	3.6	13	...	...	...	...	...	...	178	92
		Minimum	3.6	6.0	0	0	0.20	11.5	8.8	...	5	...	...	...	...	...	...	126	75
		No. of Samples	13	13	13	11	2	10	13	13	11	...	...	...	...	...	4	2	2

TABLE 20—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ST. CLAIR—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
I—IV—VI (Continued) Ship Channel, Windmill Pte. to St. Clair Flats	6.0	Median	23.0																
		Average		7.5	9.3	0.005	0.20	17.5	9.8	0.41	9							147	78
		Maximum	1,100	9.9	35	0.06	0.25	24.0	11.2	1.4	13							158	82
		Minimum	3.6	6.1	0	0	0.15	12.0	8.8	0	5							136	74
		No. of Samples	13	13	13	11	2	10	13	13	11						4	2	2
	7.0	Median	23																
		Average		7.5	11.1	0.025	0.20	17.5	10.0	0.39	9							141	70
		Maximum	>2,400	9.2	35	0.26	0.30	25.0	12.0	1.2	24							162	106
		Minimum	1.8	5.8	0	0	0.10	11.5	8.6	0.16	6							120	34
		No. of Samples	13	13	13	11	2	10	13	13	11						4	2	2
	8.0(IV)			For Point IV Refer to Range III—IV—VIII															
	10.0	Median	53																
		Average		7.0	7.2	0.017	0.23	17.0	10.2	0.66	8							165	91
		Maximum	1,100	10.5	25	0.16	0.25	24.5	11.4	2.4	19							190	106
		Minimum	<2.3	4.8	0	0	0.20	13.5	8.9	0.15	4							140	76
		No. of Samples	11	11	11	9	2	7	11	11	11						2	2	2
	13.0	Median	33																
		Average		6.3	5.5	0.002	0.23	17.5	10.4	0.46	8							151	94
		Maximum	>2,400	8.3	15	0.01	0.30	25.5	11.2	1.4	17							156	96
		Minimum	<2.3	4.2	0	0	0.15	14.0	8.9	0.23	5							146	92
		No. of Samples	11	11	11	9	2	9	11	11	11						2	2	2
	15.0(VI)	Median	93																
		Average		5.9	9.0	0.0004	0.20	17.5	10.0	0.42	8							110	49
		Maximum	>2,400	7.4	60	0.006	0.25	28.5	12.8	3.0	21							144	74
		Minimum	1.8	4.2	0	0	0.15	11.0	7.9	0	2							88	30
		No. of Samples	25	27	27	23	2	20	27	27	27						10	2	2
	0.0(IV)			For Point IV, Refer to Range III—IV—VIII															
IV—S Buoy 23 to Point Huron	2.0	Median	130																
		Average		5.8	1	0			10.8	0.41	10								
		Maximum	240	6.8	2	0			10.9	0.52	13								
		Minimum	23	4.7	0	0			10.7	0.30	7								
		No. of Samples	2	2	2	2			2	2	2								
	4.0	Median	380																
		Average		6.5	2.5	0.02			10.75	0.44	13								
		Maximum	750	6.8	5	0.04			10.8	0.48	16								
		Minimum	9.1	6.2	0	0			10.7	0.40	9								
		No. of Samples	2	2	2	2			2	2	2								
	6.0	Median	160																
		Average		6.2	1	0			10.7	0.38	12								
		Maximum	240	6.9	2	0			10.8	0.44	13								

		Minimum	75	5.5	0	0	....	....	10.5	0.32	10	....	....	....	....	....	....	....	....
		No. of Samples	2	2	2	2	....	....	2	2	2	....	....	....	....	....	....	....	....
	8.0	Median	140																
		Average	....	6.0	1	0	....	....	11.0	0.45	10	....	....	....	....	....	....	....	....
		Maximum	240	6.0	2	0	....	....	11.1	0.46	11	....	....	....	....	....	....	....	....
		Minimum	43	6.0	0	0	....	....	10.9	0.44	8	....	....	....	....	....	....	....	....
		No. of Samples	2	2	2	2	....	....	2	2	2	....	....	....	....	....	....	....	....
	0.0(I)			For Point I, Refer to Range I—II—III															
I—V—IX South Shore, Windmill Pte. to Belle River, Canada to Thames River	1.0	Median	9.1																
		Average	....	6.8	4.9	0.003	0.23	16.5	9.75	0.33	10	....	....	....	....	....	....	159	81
		Maximum	93	12.0	25	0.04	0.30	23.0	11.4	0.59	24	....	....	....	....	....	....	190	92
		Minimum	<1.8	4.2	0	0	0.15	11.0	8.8	0	6	....	....	....	....	....	....	128	70
		No. of Samples	14	14	14	12	2	11	14	14	12	....	....	....	....	....	2	2	2
	2.0	Median	4.5																
		Average	....	6.7	14.5	0.03	0.20	14.0	9.7	0.44	10	....	....	....	....	....	....	161	84
		Maximum	43	11.0	75	0.32	0.25	24.0	10.8	1.6	19	....	....	....	....	....	....	172	94
		Minimum	<1.8	4.2	0	0	0.15	12.0	8.7	0.02	5	....	....	....	....	....	....	150	74
		No. of Samples	13	13	13	11	2	11	13	13	11	....	....	....	....	....	4	2	2
	4.0	Median	3.6																
		Average	....	6.4	5.6	0.003	0.23	17.0	9.8	0.41	11	....	....	....	....	....	....	164	77
		Maximum	14	8.3	30	0.04	0.30	24	10.7	0.80	17	....	....	....	....	....	....	176	64
		Minimum	<1.8	4.6	0	0	0.15	12	8.7	0.06	6	....	....	....	....	....	....	152	90
		No. of Samples	14	14	14	12	2	11	14	14	12	....	....	....	....	....	4	2	2
	6.0	Median	3.6																
		Average	....	6	4.8	0.006	0.20	14.0	9.6	0.31	11	....	....	....	....	....	....	154	75
		Maximum	9.1	7.8	18	0.06	0.25	25.0	10.9	0.60	18	....	....	....	....	....	....	160	56
		Minimum	1.8	3.4	0	0	0.15	11.5	8.5	0	6	....	....	....	....	....	....	148	94
		No. of Samples	12	12	12	10	2	9	12	12	10	....	....	....	....	....	3	2	2
	8.0	Median	<2.3																
		Average	....	6.4	4.6	0.029	0.20	17.0	9.6	0.28	13	....	....	....	....	....	....	148	75
		Maximum	15	9.7	35	0.22	0.25	26.0	11.3	0.59	38	....	....	....	....	....	....	152	90
		Minimum	<1.8	3.4	0	0	0.15	10.5	8.5	0	6	....	....	....	....	....	....	144	60
		No. of Samples	12	12	12	10	2	9	12	12	10	....	....	....	....	....	3	2	2
	10.0	Median	3.6																
		Average	....	6.2	6.75	0.027	0.25	17.0	9.5	0.38	14	....	....	....	....	....	....	....	....
		Maximum	23	8.5	40	0.24	0.30	25.5	11.2	0.80	39	....	....	....	....	....	....	....	....
		Minimum	<1.8	4.0	0	0	0.20	11.0	8.4	0	5	....	....	....	....	....	....	....	....
		No. of Samples	12	12	12	10	2	9	12	12	10	....	....	....	....	....	3	....	....
	11.0(V)	Median	9.1																
		Average	....	6.3	11.2	0.04	0.28	21.0	9.2	8.8	15	....	....	....	....	....	....	172	111
		Maximum	240	8.5	60	0.18	0.40	26.0	10.5	3.5	43	....	....	....	....	....	....	188	126
		Minimum	<1.8	4.2	0	0	0.15	16.5	8.0	0.12	4	....	....	....	....	....	....	156	96
		No. of Samples	13	11	13	8	2	8	13	13	11	....	....	....	....	....	4	2	2
	13.5	Median	3.6																
		Average	....	6.7	12.4	0.033	0.70	21.0	9.2	7.9	12	....	....	....	....	....	....	199	112
		Maximum	9.1	7.6	60	0.18	0.90	26.0	10.0	3.0	25	....	....	....	....	....	....	216	106
		Minimum	2	5.1	0	0	0.50	17.5	8.1	0.13	4	....	....	....	....	....	....	182	118
		No. of Samples	8	7	8	6	2	5	8	8	8	....	....	....	....	....	2	2	2

TABLE 20—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ST. CLAIR—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
I—V—IX (Continued South Shore, Windmill Pte. to Belle River, Canada to Thames River	16.0	Median	3.3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	6.6	11.6	0.014	0.48	21.0	9.1	0.64	15	...	...	...	...	...	...	193	95
		Maximum	9.1	7.8	80	0.06	0.50	26.5	9.8	2.4	32	...	...	...	...	...	...	204	76
		Minimum	<1.8	5.2	0	0	0.45	17.5	8.2	0.16	5	...	...	...	...	...	...	182	114
		No. of Samples	8	7	8	6	2	5	8	8	8	...	...	...	...	...	2	2	2
	18.5	Median	3.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	6.1	2.75	0.009	0.45	20.5	9.1	7.9	16	...	...	...	...	...	...	206	114
		Maximum	31	7.4	12	0.04	0.50	26.5	9.8	2.8	36	...	...	...	...	...	...	220	106
		Minimum	<2.3	4.6	0	0	0.40	17.5	8.0	0.10	6	...	...	...	...	...	...	192	122
		No. of Samples	8	7	8	6	2	5	8	8	8	...	...	...	...	...	2	2	2
	21.0	Median	3.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	6.3	5.75	0.014	0.53	21.5	9.1	0.81	17	...	...	...	...	...	...	207	121
		Maximum	150	7.8	18	0.04	0.60	17.5	9.6	2.0	38	...	...	...	...	...	...	232	124
		Minimum	1	4.4	0	0	0.45	26.5	8.1	0.20	4	...	...	...	...	...	...	182	118
		No. of Samples	8	7	8	6	2	5	8	8	8	...	...	...	...	...	2	2	2
	22.0	Median	3.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	6.2	17.9	0.06	0.60	21.5	8.85	7.1	22	...	...	...	...	...	...	191	106
		Maximum	930	8.2	95	0.16	0.70	26.5	9.6	1.8	77	...	...	...	...	...	...	192	92
		Minimum	<1.8	4.2	0	0	0.50	17.5	8.2	0.26	5	...	...	...	...	...	...	190	120
		No. of Samples	7	7	8	6	2	5	8	8	8	...	...	...	...	...	2	2	2
	23.0	Median	3.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	6.1	7	0.03	0.45	21.5	8.85	6.15	20	...	...	...	...	...	...	179	97
		Maximum	930	8.0	25	0.13	0.60	26.5	9.6	1.6	65	...	...	...	...	...	...	208	128
		Minimum	2.0	4.2	0	0	0.30	17.5	8.3	0.20	5	...	...	...	...	...	...	150	68
		No. of Samples	8	7	8	6	2	5	8	8	8	...	...	...	...	...	2	2	2
	24.0(IX)			For Point IX, Refer to Range Th—IX—VIII—CE															
V—IV Belle River to Buoy 23 (Ship Channel)	0.0(V)	Median	9.1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	6.3	11.2	0.04	0.25	21.0	9.2	8.8	15	...	...	...	...	...	...	172	111
		Maximum	240	8.5	60	0.18	0.40	26.0	10.5	3.5	43	...	...	...	...	...	...	188	126
		Minimum	<1.8	4.2	0	0	0.15	16.5	8.0	0.28	4	...	...	...	...	...	...	156	96
		No. of Samples	13	11	13	8	2	8	13	13	11	...	...	...	...	...	...	2	2
	1.0	Median	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	6.7	3.6	0.013	0.25	18.0	9.6	0.39	14	...	...	...	...	...	...	159	83
		Maximum	43	9.2	10	0.08	0.30	26.0	10.8	0.80	37	...	...	...	...	...	...	170	76
		Minimum	<1.8	4.7	0	0	0.20	12.0	8.6	0	4	...	...	...	...	...	...	148	90
		No. of Samples	8	8	8	6	2	6	8	8	7	...	...	...	...	...	2	2	2
	2.0	Median	<2.3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	6.6	4	0.014	0.20	18.0	9.6	0.36	13	...	...	...	...	...	...	147	72
		Maximum	23	9.2	15	0.08	0.25	26.0	11.3	0.86	29	...	...	...	...	...	...	150	86
		Minimum	<1.8	4.8	0	0	0.15	11.5	8.7	0	4	...	...	...	...	...	...	144	58
		No. of Samples	8	8	8	6	2	6	8	8	7	...	...	...	...	...	2	2	2

	4.0	Median	<2.3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	6.7	7.9	0.011	0.18	17.5	9.6	0.37	12	...	...	...	...	...	...	145	74
		Maximum	43	9.5	17	0.06	0.25	25.5	11.0	0.47	33	...	...	...	...	...	...	152	86
		Minimum	<1.8	4.6	0	0	0.10	12.5	8.5	0	4	...	...	...	...	...	...	138	62
		No. of Samples	8	8	8	6	2	6	8	8	7	...	...	...	...	...	2	2	2
	6.0	Median	38	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	7.1	3.5	0.013	0.20	17.5	9.9	0.31	8	...	...	...	...	...	...	149	82
		Maximum	93	8.3	10	0.08	0.30	25.0	10.8	0.59	15	...	...	...	...	...	...	150	70
		Minimum	<1.8	5.2	0	0	0.10	12.0	8.7	0	4	...	...	...	...	...	...	148	94
		No. of Samples	8	8	8	6	2	6	8	8	7	...	...	...	...	...	2	2	2
	8.0	Median	150	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	7.0	3.0	0.008	0.23	17.0	10.2	0.45	9	...	...	...	...	...	...	150	79
		Maximum	>2,400	9.2	10	0.06	0.30	25.0	11.2	1.0	15	...	...	...	...	...	...	152	90
		Minimum	1.8	5.0	0	0	0.15	11.0	8.9	0.02	5	...	...	...	...	...	...	148	68
		No. of Samples	10	10	10	7	2	6	10	10	9	...	...	...	...	...	2	2	2
	9.0	Median	22	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	7.1	3.1	0.001	0.23	16.5	10.2	0.45	7	...	...	...	...	...	...	148	70
		Maximum	290	11.0	7	0.01	0.30	26.0	11.4	1.2	11	...	...	...	...	...	...	152	78
		Minimum	<1.8	4.1	0	0	0.15	11.0	9.0	0.24	4	...	...	...	...	...	...	144	62
		No. of Samples	10	10	10	8	2	8	10	10	9	...	...	...	...	...	2	2	2
	10.0(IV)			For Point IV, Refer to Range III—IV—VIII															
Th—IX—VIII—CE East Shore, Thames River to outer Thames Buoy to Chenal Ecarte	0.0(Th)	Median	490	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	11.3	4.4	0.053	0.65	21.0	7.6	1.7	29	...	...	...	...	...	...	380	215
		Maximum	11,000	19.2	20	0.16	0.80	27.5	10.4	3.8	65	...	...	...	...	...	...	440	252
		Minimum	3.7	6.2	0	0	0.50	17.5	5.4	0.64	10	...	...	...	...	...	...	320	178
		No. of Samples	11	9	11	8	2	7	11	11	10	...	...	...	...	...	5	2	2
	1.0(IX)	Median	53	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	7.3	3.2	0.02	0.60	23.0	8.7	0.96	20	...	...	...	...	...	...	205	112
		Maximum	2,400	10.8	15	0.10	0.80	26.5	10.4	2.6	52	...	...	...	...	...	...	230	120
		Minimum	<2.3	4.5	0	0	0.40	17.0	7.4	0.40	7	...	...	...	...	...	...	180	104
		No. of Samples	10	9	10	8	2	7	10	10	10	...	...	...	...	...	5	2	2
	2.5(VIII)	Median	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	6.6	5.5	0.016	0.48	22.5	8.1	0.83	20	...	...	...	...	...	...	182	112
		Maximum	150	8.5	20	0.05	0.60	26.5	9.6	3.0	73	...	...	...	...	...	...	208	124
		Minimum	<2.3	4.8	0	0	0.35	17.0	8.1	0.27	5	...	...	...	...	...	...	158	94
		No. of Samples	11	11	11	9	3	8	12	12	12	...	...	...	...	...	4	3	3
	5.0	Median	<2.3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	6.7	1.4	0.006	0.38	25.0	8.7	0.53	9	...	...	...	...	...	...	176	103
		Maximum	15	7.8	6	0.03	0.40	27.0	9.2	1.8	24	...	...	...	...	...	...	180	102
		Minimum	<1.8	6.0	0	0	0.35	20.0	8.1	0	5	...	...	...	...	...	...	172	104
		No. of Samples	7	6	7	5	2	5	7	7	7	...	...	...	...	...	3	2	2
	7.5	Median	3.1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	6.9	3.6	0	0.40	24.5	9.2	0.84	12	...	...	...	...	...	...	163	103
		Maximum	9.1	8.0	18	0	0.50	27.5	10.0	3.4	49	...	...	...	...	...	...	164	94
		Minimum	1	5.8	0	0	0.30	18.0	8.6	0	4	...	...	...	...	...	...	162	112
		No. of Samples	6	6	7	5	2	5	7	7	7	...	...	...	...	...	3	2	2

TABLE 20—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ST. CLAIR—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
Th—IX—VIII—CE (Continued) East Shore, Thames River to outer Thames Buoy to Chenal Ecarte	10.5	Median	93	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	6.3	4	0.005	0.51	22.0	9.7	0.94	12	....	....	....	....	....	....	149	74
		Maximum	460	7.8	14	0.02	0.87	27.5	10.8	3.2	21	....	....	....	....	....	....	174	52
		Minimum	1.0	5.0	0	0	0.30	12.0	8.3	0.09	4	....	....	....	....	....	....	113	82
		No. of Samples	9	7	9	6	3	6	9	9	9	....	....	....	....	....	5	3	3
	11.0	Median	240	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	6.5	7.9	0.03	0.58	20.5	9.5	0.74	18.7	....	....	....	....	....	....	163	83
		Maximum	930	8.0	25	0.01	1.1	28.0	10.5	3.0	60	....	....	....	....	....	....	204	84
		Minimum	7.8	5.4	0	0	0.30	12.0	8.1	0.20	5	....	....	....	....	....	....	128	76
		No. of Samples	9	7	9	6	3	6	9	9	9	....	....	....	....	....	5	3	3
	11.5(CE)	Median	340	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	6.4	2.3	0.002	0.45	20.0	9.4	0.56	15	....	....	....	....	....	....	177	86
		Maximum	2,400	7.4	7	0.01	0.80	23.0	10.8	1.0	27	....	....	....	....	....	....	182	118
		Minimum	33	5.0	0	0	0.25	14.5	8.2	0	5	....	....	....	....	....	....	160	110
		No. of Samples	8	6	7	5	3	5	8	8	7	....	....	....	....	....	3	3	3
VII—X—VI Mitchell Pte. to St. Clair Flats	0(VII)	Median	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Maximum	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Minimum	2	8.7	16	....	0.35	....	9.8	0.80	9	....	....	....	....	....	....	160	104
		No. of Samples	1	1	1	....	1	....	1	1	1	....	....	....	....	....	....	1	1
	0.5	Median	3.6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	6.7	7.5	0.008	0.75	21.5	9.6	0.87	11	....	....	....	....	....	....	179	48
		Maximum	79	8.5	20	0.05	1.10	28.5	10.8	1.4	21	....	....	....	....	....	....	192	20
		Minimum	1.8	4.7	0	0	0.40	11.0	8.0	0.48	5	....	....	....	....	....	....	166	76
		No. of Samples	8	7	8	6	2	6	8	8	8	....	....	....	....	....	4	2	2
	1.5	Median	8.7	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	6.6	2.9	0.001	0.75	22.5	9.5	8.9	9	....	....	....	....	....	....	192	79
		Maximum	130	7.8	9	0.004	1.20	27.5	10.3	2.6	15	....	....	....	....	....	....	192	106
		Minimum	1.8	5.3	0	0	0.30	11.0	8.3	0.14	5	....	....	....	....	....	....	192	36
		No. of Samples	8	7	8	6	2	6	8	8	8	....	....	....	....	....	4	2	2
	2.5	Median	3.6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	6.25	6	0.05	0.73	21.0	9.7	0.94	10	....	....	....	....	....	....	202	73
		Maximum	4.9	7.8	25	0.26	1.10	26.5	11.4	2.8	18	....	....	....	....	....	....	206	54
		Minimum	1.8	5.1	0	0	0.35	11.0	8.8	0.50	7	....	....	....	....	....	....	198	92
		No. of Samples	7	6	7	5	2	5	7	7	7	....	....	....	....	....	3	2	2
	3.5	Median	<23	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	6.55	9.2	0.001	0.70	17.0	10.3	1.39	9	....	....	....	....	....	....	153	58
		Maximum	15	8.3	30	0.004	1.10	23.5	11.6	3.6	15	....	....	....	....	....	....	206	38
		Minimum	1.8	5.1	2	0	0.30	11.0	8.8	0.42	7	....	....	....	....	....	....	100	78
		No. of Samples	5	4	5	3	2	3	5	5	5	....	....	....	....	....	1	2	2

	5.5	Median	15																
		Average		6.3	3.8	0	0.23	19.0	10	0.37	6							132	49
		Maximum	93	7.6	12	0	0.25	24.0	11.5	0.66	9							136	62
		Minimum	<1.8	5.1	0	0	0.21	11.0	9.1	0	3							128	36
		No. of Samples	8	7	8	6	2	5	8	8	8						4	2	2
	7.5	Median	9.1																
		Average		6.65	4.6	0	0.29	20.5	10.1	0.53	5							121	48
		Maximum	23	8.0	8	0	0.38	26.5	11.5	1.4	7							138	46
		Minimum	1.8	5.2	0	0	0.20	11.0	8.9	0	2							104	50
		No. of Samples	7	6	7	5	2	5	7	7	7						3	2	2
	9.5(X)	Median	9.1																
		Average		6.2	5.2	0.007	0.27	16.0	10.1	0.65	5							122	50
		Maximum	1,100	7.8	25	0.05	0.30	26.5	11.4	2.2	8							154	86
		Minimum	<2.3	4.5	0	0	0.19	11.0	7.9	0	2							86	24
		No. of Samples	11	9	11	7	4	7	11	11	11						4	3	3
	11.5	Median	3.6																
		Average		6.12	5	0	3.83	16.5	9.7	0.42	6							102	40
		Maximum	43	7.6	15	0	7.3	26.5	10.7	1.0	12							124	56
		Minimum	1.8	4.7	0	0	0.35	11.0	8.8	0	3							80	24
		No. of Samples	11	10	11	10	2	8	11	11	11						4	2	2
	13.5	Median	6.3																
		Average		6.2	10.1	0.002	4.9	19.0	0.85	0.44	7							110	50
		Maximum	93	8.3	50	0.02	9.4	26.0	8.7	0.80	11							128	76
		Minimum	1.8	4.7	0	0	0.35	11.0	10.8	0.15	2							92	24
		No. of Samples	12	11	12	11	2	9	12	12	12						4	2	2
	15.0(VI)			For Point VI, Refer to Range IV—VI															
X—V Mouth of Bassett Channel to Belle River	0.0(X)	Median	9.1																
		Average		6.2	5.2	0.007	0.27	16.0	10.1	0.65	5							122	50
		Maximum	1,100	7.8	25	0.05	0.30	26.5	11.4	2.2	8							154	86
		Minimum	<2.3	4.5	0	0	0.19	11.0	7.9	0	2							86	24
		No. of Samples	11	9	11	7	4	7	11	11	11							3	3
	1.0	Median	22																
		Average		6.7	24	0.02	0.20	17.0	10.2	0.93	8							160	72
		Maximum	240	9.2	60	0.04	0.20	20.0	11.1	1.8	9							174	72
		Minimum	<1	5.4	0	0	0.20	14.0	9.2	0.10	4							146	72
		No. of Samples	4	3	4	2	2	2	4	4	4						1	2	2
	2.0	Median	5																
		Average		6.1	5.5	0	0.30	18.5	9.9	1.43	6							152	76
		Maximum	9.1	7.4	13	0	0.30	20	10.4	2.9	7							160	76
		Minimum	<1	5.3	0	0	0.30	17.0	9.4	0.24	4							144	76
		No. of Samples	4	3	4	2	2	2	4	4	4						1	2	2
	4.0	Median	<2.3																
		Average		6.3	12	0.003	0.33	19.0	9.5	8.7	11							164	83
		Maximum	3.3	8.7	25	0.006	0.45	20	10.0	2.5	17							186	100
		Minimum	1.0	5.0	7	0	0.20	17.5	9.1	0	4							142	66
		No. of Samples	4	3	4	2	2	2	4	4	4						1	2	2

TABLE 20—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ST. CLAIR—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N₂ ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
X—V (Continued) Mouth of Bassett Channel to Bell River	6.0	Median	1.0																
		Average		6.9	2	0.003	0.35	18.0	9.6	0.55	10							182	90
		Maximum	<2.3	8.7	8	0.006	0.40	19.5	10.4	1.0	18							238	140
		Minimum	<1.0	5.1	0	0	0.30	16.5	9.0	0.25	7							136	40
		No. of Samples	4	4	4	2	2	2	4	4	4						1	2	2
	9.0	Median	<2.3																
		Average		6.6	14.5	0.004	0.33	19.5	9.4	1.47	16							170	90
		Maximum	3.3	8.7	35	0.008	0.45	21.0	10.0	3.0	26							194	104
		Minimum	1.0	5.2	2	0	0.20	18.0	8.9	0.20	4							146	76
		No. of Samples	4	3	4	2	2	2	4	4	4						1	2	2
	12.0	Median	2																
		Average		3.6	9.7	0.005	0.45	20.0	9.2	1.29	17							192	107
		Maximum	<2.3	4.9	18	0.01	0.45	21.5	9.7	3.9	24							200	114
		Minimum	<1.0	2.4	6	0	0.45	19.0	8.8	0.04	8							184	100
		No. of Samples	4	3	4	2	2	2	4	4	4						1	2	2
	13.0	Median	<2.3																
		Average		5.4	11.8	0.003	0.50	19.5	9.3	1.01	15							206	110
		Maximum	5.5	6.4	18	0.006	0.55	20.5	9.5	2.1	15							228	124
		Minimum	1.0	4.4	5	0	0.45	18.5	8.9	0.44	14							184	96
		No. of Samples	4	3	4	2	2	2	4	4	4						1	2	2
	15.0			For Point V, Refer to Range I—V—IX															
CL—E Mouth of Clinton River to Strawberry Island	0.0(CL)	Median	2,400																
		Average		29.2	8.2	0.16	0.30	20.5	8.15	1.68	35							145	103
		Maximum	24,000	150	50	0.40	0.30	28.0	11.9	4.1	140							150	118
		Minimum	<1.8	8.4	0	0	0.30	11.0	4.7	0.18	5							140	88
		No. of Samples	20	19	20	18	2	17	20	20	19						7	2	2
	0.5	Median	9.1																
		Average		7.3	2.7	0.006	0.30	19.0	9.9	0.51	13								
		Maximum	4,600	10.2	20	0.06	0.30	27.0	11.2	1.6	56								
		Minimum	<1.8	5.3	0	0	0.30	11.0	8.3	0.02	3							154	100
		No. of Samples	17	18	18	7	1	16	18	18	18						8	1	1
	1.0	Median	23																
		Average		7.3	4.7	0.005	0.25	18.0	10.2	0.385	8								
		Maximum	930	11.1	20	0.06	0.25	26.5	11.7	1.0	15								
		Minimum	<1.8	5.6	0	0	0.25	11.0	8.9	0.10	4							130	86
		No. of Samples	16	16	16	15	1	14	16	16	16						5	1	1
	1.5	Median	340																
		Average		7.4	2.7	0.001	0.30	17.0	10.2	3.9	9								
		Maximum	930	12.1	25	0.01	0.30	25.0	11.7	1.4	30								
		Minimum	43	5.6	0	0	0.30	11.0	9.2	0.04	3							130	62
		No. of Samples	16	17	17	16	1	15	17	17	17						6	1	1

Cl—E Mouth of Clinton River to Strawberry Island	2.0	Median	430																
		Average		7.2	4.1	0	0.30	17.0	9.9	0.88	8								
		Maximum	2,400	11.7	25	0	0.30	25.5	11.6	8.2	17							134	70
		Minimum	240	5.1	0	0	0.30	9.5	8.3	0.12	3						7	1	1
		No. of Samples	16	16	16	3	1	14	16	16	16								
	2.5	Median	430																
		Average		7	8.25	0.016	0.25	17.0	9.97	0.397	8								
		Maximum	2,400	11.1	65	0.20	0.25	25.5	11.7	0.86	22							116	60
		Minimum	93	5.0	0	0	0.25	10.0	8.5	0.04	3						6	1	1
		No. of Samples	16	16	16	15	1	14	16	16	16								
	3.0(E)	Median	930																
		Average		7.3	12.1	0.003	0.30	17.5	9.9	9.1	8								
		Maximum	1,100	12.0	115	0.04	0.30	25.5	11.4	9.2	28							160	102
		Minimum	78	5.0	0	0	0.30	10.0	8.2	0	4						6	1	1
		No. of Samples	15	15	15	14	1	13	15	15	15								
Cl—N Belvidere Bay	0.0(Cl)			For Point Cl, Refer to Range Cl—E															
	0.5	Median	15																
		Average		8.3	11.5	0.008	0.25	21.0	9.7	0.42	13								
		Maximum	1,100	20.0	110	0.08	0.25	28.0	10.9	1.4	48							138	80
		Minimum	<1.8	5.9	0.0	0	0.25	11.0	8.3	0.12	4						7	1	1
		No. of Samples	13	13	13	12	1	12	13	13	13								
	1.0(N)	Median	23																
		Average		7.8	5		0.50	20.0	9.5	0.71	12								
		Maximum	430	12.5	25	0.24	0.50	28.0	10.7	2.0	40							256	176
		Minimum	<1.8	5.7	0	0	0.50	11.0	8.0	0.18	5						7	1	1
		No. of Samples	13	13	13	12	1	12	13	13	13								
Cl—S Mouth of Clinton River to Point Huron	0.0(Cl)			For Point Cl, Refer to Range Cl—E															
	0.5	Median	43																
		Average		8.0	6.8	0.047	0.25	18.5	9.8	0.55	14								
		Maximum	4,300	18.1	100	0.26	0.25	27.5	10.9	1.5	60							120	48
		Minimum	<1.8	5.7	0	0	0.25	11.0	6.4	0.21	3						7	1	1
		No. of Samples	18	18	18	17	1	16	17	17	18								
	1.0	Median	23																
		Average		7.3	7.2	0.02	0.35	16.5	10.1	0.43	12								
		Maximum	1,500	11.3	52	0.30	0.35	27.5	10.9	1.2	50							110	46
		Minimum	<1.8	5.4	0	0	0.35	11.0	9.4	0	4						7	1	1
		No. of Samples	18	18	18	17	1	16	18	18	18								
	1.5	Median	33																
		Average		7.5	3.67	0.02	0.37	18.0	9.9	0.53	12								
		Maximum	4,300	11.1	20	0.16	0.37	28.5	10.9	1.6	58							120	54
		Minimum	<1.8	6.0	0	0	0.37	11.0	8.5	0	4						7	1	1
		No. of Samples	18	18	18	17	1	16	18	18	18								
	2.0(S)			For Point S, Refer to Range S—VI															
S—VI Point Huron—South East to Ship Channel	2.0(S)	Median	93																
		Average		9.4	5.8	0.035	0.25	18.5	9.4	0.80	23								
		Maximum	24,000	23.0	35	0.34	0.25	27.5	12.0	2.2	71							116	52
		Mininum	1.0	5.3	0	0	0.25	11.0	5.7	0.07	3						7	1	1
		No. of Samples	19	19	19	18	1	16	19	19	19								

TABLE 20—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ST. CLAIR—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Tests	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
S—VI (Continued) Point Huron—South East to Ship Channel	2.5	Median	43																
		Average		7.1	15	0.016		19.5	10.2	0.33	9								
		Maximum	2,400	10.9	150	0.16		25.0	11.6	0.66	23								
		Minimum	3	5.0	0	0		11.0	8.7	0.02	5								
		No. of Samples	14	14	14	14	0	12	14	14	14						6		
	3.0	Median	210																
		Average		7	3.4	0.009		17.0	10.3	0.40	8								
		Maximum	1,100	10.6	30	0.12		24.5	11.9	0.87	13								
		Minimum	23	5.5	0	0		10.0	8.5	0.03	3								
		No. of Samples	14	14	14	14	0	12	14	14	14						6		
	4.0	Median	240																
		Average		6.9	5.8	0		18.5	10.1	0.31	8								
		Maximum	1,100	11.2	45	0		24.5	11.8	0.57	12								
		Minimum	39	5.0	0	0		10.0	8.4	0.06	3								
		No. of Samples	14	14	14	14	0	12	14	14	14						6		
	5.0	Median	240																
		Average		6.9	1.6	0.001		18.5	10.2	0.395	9								
		Maximum	>2,400	11.3	12	0.02		23.5	11.6	1.1	28								
		Minimum	23	3.8	0	0		11.0	8.8	0.06	5								
		No. of Samples	14	14	14	14	0	12	14	14	14						6		
	6.0	Median	230																
		Average		6.6	8.1	0.017		18.0	10.2	0.36	9								
		Maximum	1,100	11.0	60	0.24		24.5	11.7	0.80	22								
		Minimum	23	4.5	0	0		11.0	8.7	0.20	5								
		No. of Samples	14	14	14	14	0	12	14	14	14						6		
	7.0	Median	43																
		Average		6.2	6.2	0.005		17.5	10.2	0.38	9								
		Maximum	430	9.9	44	0.06		23.5	11.8	0.70	27								
		Minimum	9.1	4.1	0	0		11.0	8.6	0.12	3								
		No. of Samples	13	14	14	14	0	12	14	14	14						6		
	8.0			For Point VI, Refer to Range I—IV—VI															
(Cl)—S—W Point Huron to Mt. Clemens W. W. Intake	2.0(S)	Median	93																
		Average		9.4	5.8	0.035	0.25	18.5	9.4	0.80	23								
		Maximum	24,000	23.0	35	0.34	0.25	27.5	12.0	2.2	71								
		Minimum	1.0	5.3	0	0	0.25	11.0	5.7	0.07	3							116	52
		No. of Samples	19	19	19	18	1	16	19	19	19							1	1
	2.5	Median	120																
		Average		9.7	3.3	0.039	0.20	21.0	9.4	0.73	16								
		Maximum	2,400	15.9	17	0.24	0.20	28.5	10.6	1.8	52								
		Minimum	3.6	6.2	0	0	0.20	11.0	0.11	4								118	66
		No. of Samples	14	14	14	13	1	13	14	14	14						7	1	1

(S)—W—XI Point Huron to Mt. Clemens W. W. Intake to St. Clair Shores Light Buoy	3.0	Median	93	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	10.7	6.75	0.026	0.30	19.0	9.6	0.96	18	....	....	....	....	....	....	....	....
		Maximum	4,600	18.0	50	0.16	0.30	28.5	11.6	2.4	58	....	....	....	....	....	....	....	....
		Minimum	9.1	5.5	0	0	0.30	11.0	8.2	0.10	4	....	....	....	....	....	....	190	116
		No. of Samples	16	16	16	15	1	15	16	16	16	....	....	....	....	....	7	1	1
	3.5	Median	140	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	10.6	9.1	0.028	0.30	19.5	9.7	0.98	15	....	....	....	....	....	....	....	....
		Maximum	4,300	18.0	35	0.12	0.30	30.0	12.2	2.6	56	....	....	....	....	....	....	156	74
		Minimum	<2.3	6.0	0	0	0.30	11.0	8.2	0.19	6	....	....	....	....	....	....	....	....
		No. of Samples	12	13	13	12	1	12	13	13	13	....	....	....	....	....	7	1	1
	4.0	Median	93	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	14.3	6.7	0.015	0.35	19.5	9.8	0.86	13	....	....	....	....	....	....	....	....
		Maximum	1,100	68.0	40	0.06	0.35	29.5	11.4	1.6	28	....	....	....	....	....	....	....	....
		Minimum	<3.6	5.6	0	0	0.35	11.0	8.4	0.26	4	....	....	....	....	....	....	150	76
		No. of Samples	17	17	17	16	1	16	17	17	17	....	....	....	....	....	7	1	1
	4.5(W)	Median	93	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	10.5	6.8	0.007	0.50	19.5	9.9	0.90	13	....	....	....	....	....	....	....	....
		Maximum	930	20.0	60	0.04	0.50	29.5	11.2	2	28	....	....	....	....	....	....	....	....
		Minimum	9.1	5.8	0	0	0.50	11.0	8.2	0.10	5	....	....	....	....	....	....	144	94
		No. of Samples	17	17	17	16	1	16	17	17	17	....	....	....	....	....	7	1	1
	5.5	Median	43	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	6.2	0	0	....	12.0	10.2	0.40	15	....	....	....	....	....	....	....	....
		Maximum	>2,400	6.8	0	0	....	13.5	10.6	0.51	18	....	....	....	....	....	....	....	....
		Minimum	43	5.6	0	0	....	11.0	9.8	0.26	10	....	....	....	....	....	....	....	....
		No. of Samples	3	3	3	3	0	3	3	3	3	....	....	....	....	....	....	....	....
	6.5	Median	43	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	6.8	0	0	....	12.5	10.03	0.38	19	....	....	....	....	....	....	....	....
		Maximum	93	8.4	0	0	....	14.0	10.6	0.57	25	....	....	....	....	....	....	....	....
		Minimum	7.3	5.8	0	0	....	11.0	9.5	0.20	13	....	....	....	....	....	....	....	....
		No. of Samples	3	3	3	3	0	3	3	3	3	....	....	....	....	....	....	....	....
	7.5	Median	150	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	6.8	0	0	....	12.5	10.1	0.34	14	....	....	....	....	....	....	....	....
		Maximum	150	7.2	0	0	....	14.0	10.6	0.48	16	....	....	....	....	....	....	....	....
		Minimum	93	6.2	0	0	....	11.0	9.7	0.24	11	....	....	....	....	....	....	....	....
		No. of Samples	3	3	3	3	0	3	3	3	3	....	....	....	....	....	....	....	....
	8.5	Median	23	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	6.8	0	0	....	12.0	10.1	0.41	20	....	....	....	....	....	....	....	....
		Maximum	43	7.9	0	0	....	13.5	10.5	0.56	30	....	....	....	....	....	....	....	....
		Minimum	9.1	6.2	0	0	....	11.0	9.7	0.27	13	....	....	....	....	....	....	....	....
		No. of Samples	3	3	3	3	....	3	3	3	3	....	....	....	....	....	....	....	....
	9.5	Median	58	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	8.0	0	0	....	12.0	10.05	0.37	11	....	....	....	....	....	....	....	....
		Maximum	93	9.0	0	0	....	13.5	10.5	0.43	13	....	....	....	....	....	....	....	....
		Minimum	23	7.0	0	0	....	11.0	9.6	0.31	9	....	....	....	....	....	....	....	....
		No. of Samples	2	2	2	2	0	2	2	2	2	....	....	....	....	....	....	....	....
	10.0(XI)	Median	23	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	7.6	0	0	....	12.0	10.1	0.44	17	....	....	....	....	....	....	....	....
		Maximum	43	10.0	0	0	....	13.0	10.5	0.54	27	....	....	....	....	....	....	....	....
		Minimum	9.1	5.8	0	0	....	11.0	9.7	0.38	10	....	....	....	....	....	....	....	....
		No. of Samples	3	3	3	3	0	3	3	3	3	....	....	....	....	....	....	....	....

States waters and at the mouths of the larger tributaries, with values reaching up to 140 p.p.m. In the central portion of the lake results were generally under 10 or 15 p.p.m. Other analytical results showed less significant effects.

Detroit River

Table 21 (see pages 107 to 135) gives the summary of average analytical results for samples taken in the Detroit River. These results show a littoral stratification similar to that experienced in the St. Clair River. The pollution tends to hug the respective shores in the upper reaches of the stream. In the lower portion, below Fighting Island, there is a spreading and diffusion of the pollution across the width of the stream. This is well illustrated in the distribution of median coliform results graphically presented in figure 9.

Highest coliform values at the entrance to the Detroit River (range Dt-30.8w and Dt-30.7e) were found near both shores, the medians approximating 100 per 100 ml. At the boundary line this value was about 10. Conner Creek, which carries the storm overflow from part of the Detroit sewer system, had a median M.P.N. value of 460,000 and a maximum figure of 24,000,000. These high values are reflected in results obtained at range Dt-29.2w, a mile and a half downstream. Here, samples taken within 50 and 100 feet from shore gave median coliform results of 200,000 and 93,000 per 100 ml., respectively. The maximum rose to 1,100,000.

Moving downstream, the bacterial pollution continues to hug the respective shores, but the zones have widened by the time range Dt-20.6, above the Rouge River, is reached. The inflow of untreated sewage and combined sewer overflows from both sides of the river causes the median values at this range to rise to over 20,000 coliforms per 100 ml. on the United States side, and to just under 10,000 on the Canadian side.

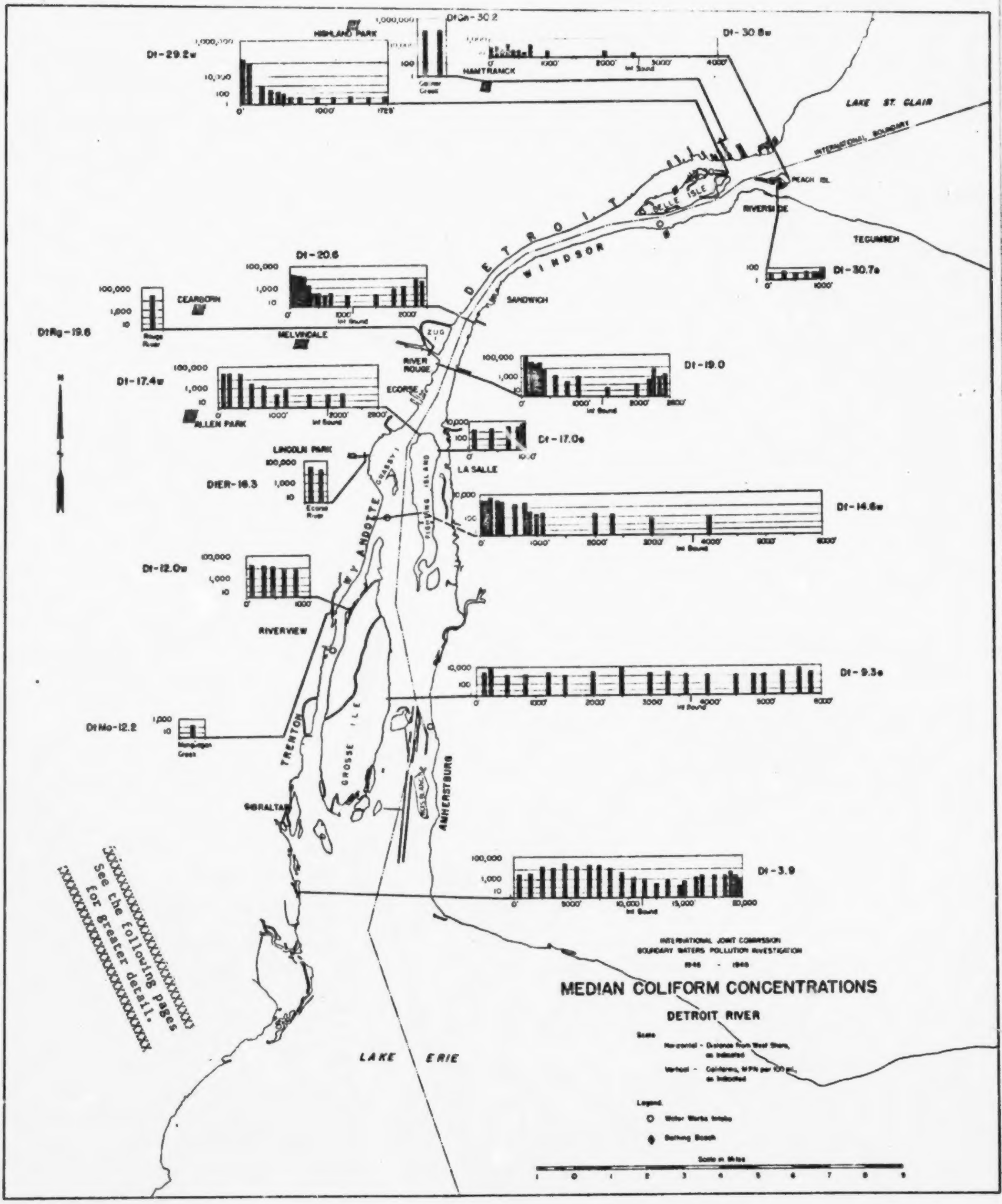
Bacterial pollution from the Rouge River and the Detroit sewage treatment plant, as shown at range Dt-19.0, causes the coliform values to rise sharply near the United States shore to 93,000 M.P.N. per 100 ml. The flow of the river splits at Fighting Island, the float studies indicated a tendency for surface currents to travel from the mouth of the Rouge River and the vicinity of Zug Island across the boundary and into the channel on the Canadian side east of Fighting Island. In this channel the bacterial pollution is more uniformly distributed. It is likely influenced by the flow from Turkey Creek on the Canadian side and by material carried across the boundary.

The pollution west of Fighting Island is divided by Grassy Island, the more heavily concentrated flow staying close to the United States shore and entering Trenton Channel, west of Grosse Ile. The flow around both sides of Fighting Island combines east of Grosse Ile, and the pollution is fairly well distributed across the channel by the time range Dt-9.3e is reached. At range Dt-3.9, across the mouth of the Detroit River, the bacterial pollution on the Canadian side remained constant at about 5,000 M.P.N., but there is an increase on the United States side. This rise, with median values reaching 43,000 per 100 ml. at some of the sampling points, is caused by the polluted waters from Trenton Channel.

Comparisons of the bacterial loads of coliform organisms at specific points in the Lake Huron-Lake Erie sections reveal significant effects of pollution increments and natural purification agencies. In approximate terms it may be stated that the load increases 200 times in passing through the St. Clair River. This then decreases to one-twentieth in passing through Lake St. Clair, and increases 300 times in passing through the Detroit River. The overall increase in coliform organisms from Lake Huron to Lake Erie is over 3,000 times.

Average phenol results for the Detroit River are contained in figure 10. The effects of discharges from the industries and other sources on the United States side are clearly shown on this chart. Average phenol concentrations above the Rouge River generally varied from zero to 6 or 7 p.p.b. Individual results for each sampling point did not vary widely, except on one occasion. This occurred on range Dt-20.6 above the Rouge River. An individual result of 450 p.p.b. created a high average at the shore sampling point. On the Canadian side the average phenols were less than 11 p.p.b.

The first significant increase in phenol concentration occurred just below the Rouge River. Average values at shore points vary from 11 to 39 p.p.b. This rise may be attributed to discharges from the Rouge River and the Detroit sewage treatment plant. Samples taken at the mouth of the Rouge River had an average phenol concentration of 79 p.p.b. and a maximum of 260. The results on the Canadian side, at range Dt-17.0e, do not show any appreciable influence of phenols from the Rouge River and Detroit sewage treatment plant. There is an increase in phenols on the Canadian side at range Dt-9.3e which may be attributed to discharges from the waste beds on Fighting Island. At range Dt-17.4w the heavier concentrations appeared near the United States shore. This polluted zone continued downstream into the Trenton Channel, where additional phenol was added from Monguagon Creek and sources located along the Detroit River. At range Dt-3.9 the phenol concentration follows, in general, the same pattern as the coliform distribution, in that there is diffusion across the river, with a higher amount on the



INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948
MEDIAN COLIFORM CONCENTRATIONS
DETROIT RIVER
Scale
Horizontal - Distance from West Shore, as indicated
Vertical - Coliforms, MPN per 100 ml., as indicated
Legend
○ Water Works Intake
◆ Bathing Beach
Scale in Miles
1 0 1 2 3 4 5 6 7 8 9
LAKE ST. CLAIR
INTERNATIONAL BOUNDARY
PEACH ISL.
RIVERSIDE
TECUMSEH
BELLE ISLE
DETROIT
WINDSOR
SANDWICH
ZUG I.
RIVER ROUGE
ECORSE
LA SALLE
FIGHTING ISLAND
GRASSY I.
WYANDOTTE
RIVERVIEW
TRENTON
GROSSE ILE
GIBRALTAR
AMHERSTBURG
LAKE ERIE
HIGHLAND PARK
HAMTRANCK
DEARBORN
MELVINDALE
ALLEN PARK
LINCOLN PARK
DI-29.2w
DIC0-30.2
Connor Creek
DI-30.8w
DI-30.7e
DI-20.6
DIRg-19.6
Rouge River
DI-19.0
DI-17.4w
DI-17.0e
DIER-16.3
Ecorse River
DI-14.6w
DI-12.0w
DI-9.3e
DIMo-12.2
Monguagon Creek
DI-3.9
Int Bound
1,000,000
100,000
10,000
1,000
100
10
1
0'
1000'
1725'
2000'
2800'
3000'
4000'
5000'
6000'
10,000
15,000
20,000

XXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXX

107-a

Figure 9

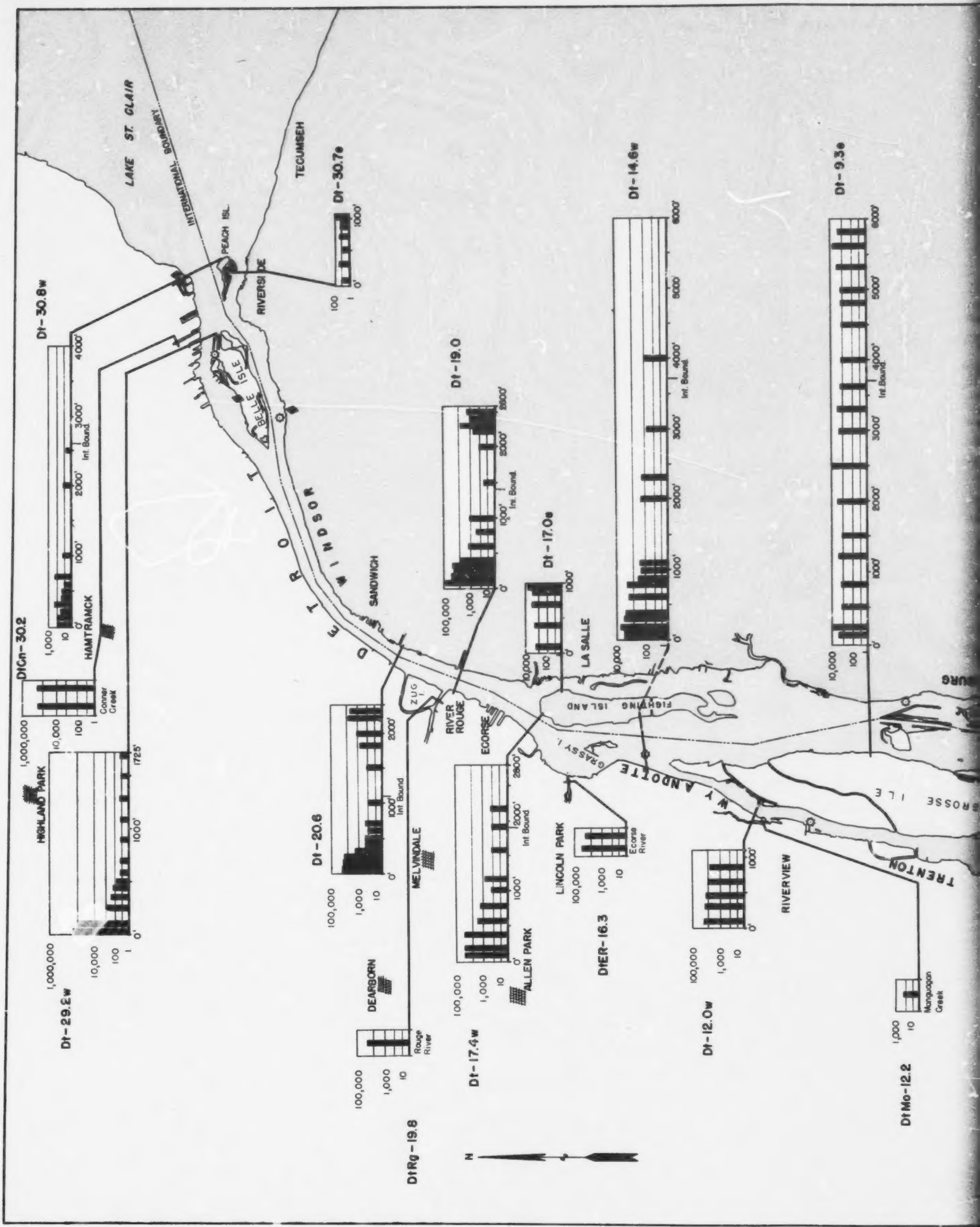
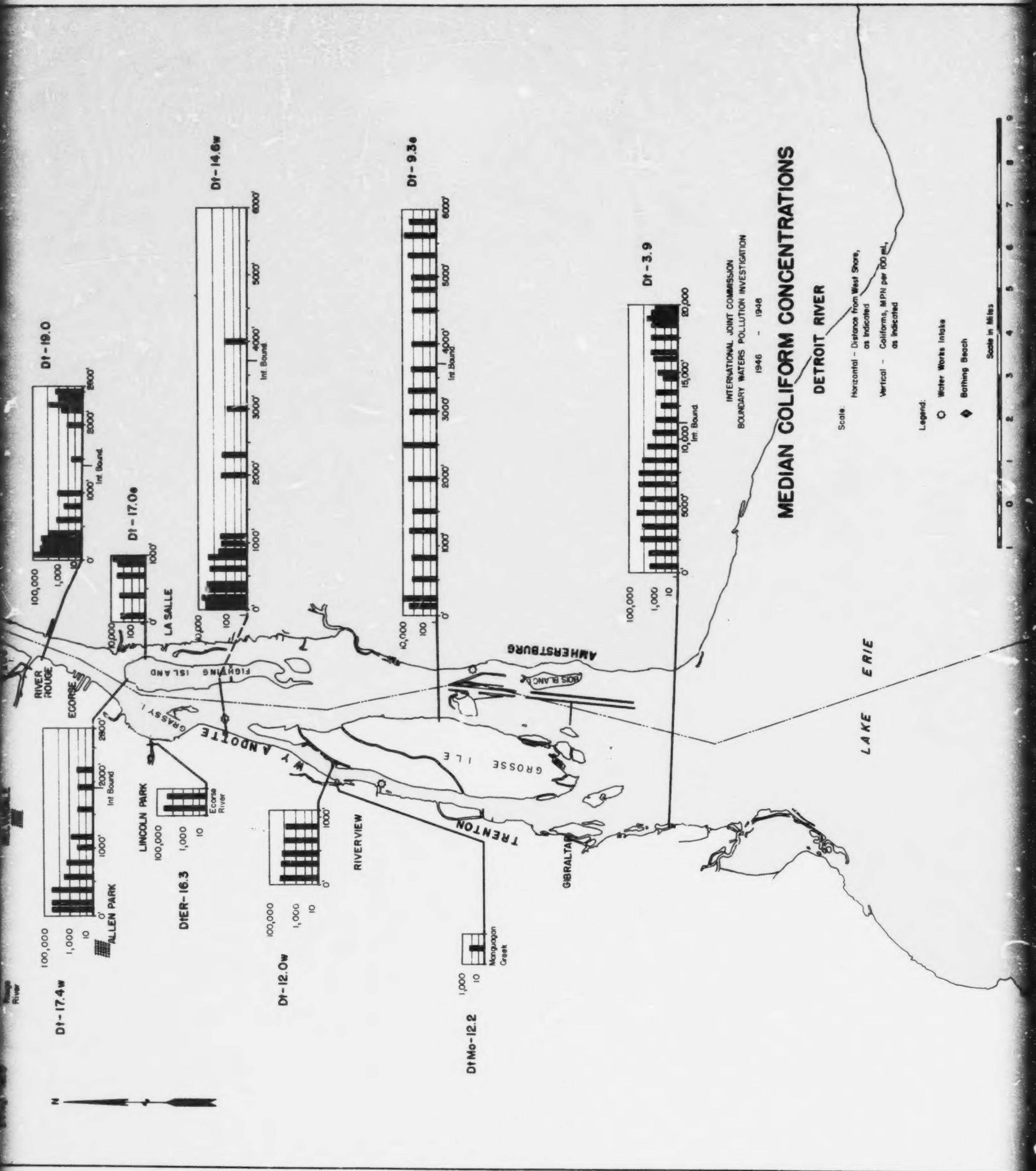

LAKE ST. CLAIR
INTERNATIONAL BOUNDARY
PEACH ISL.
TECUMSEH
RIVERSIDE
BELLE ISLE
DETROIT
WINDSOR
SANDWICH
HAMTRAMCK
HIGHLAND PARK
DEARBORN
MELVINDALE
ZUG I.
RIVER ROUGE
ECORSE
LA SALLE
FIGHTING ISLAND
GRASSY I.
WYANDOTTE
GROSSE ILE
LINCOLN PARK
ALLEN PARK
RIVERVIEW
TRENTON
Dt-30.8w
Dt-30.7e
DtCn-30.2
Dt-29.2w
Dt-20.6
Dt-19.0
DtRg-19.8
Dt-17.4w
Dt-17.0e
DtER-16.3
Dt-14.6w
Dt-12.0w
DtMo-12.2
Dt-9.3e
Conner Creek
Rouge River
Ecorse River
Monguagon Creek
Int Bound
1,000,000
100,000
10,000
1,000
100
10
1
0'
1000'
1725'
2000'
2600'
2800'
3000'
4000'
5000'
6000'
N

Figure 9



MEDIAN COLIFORM CONCENTRATIONS
DETROIT RIVER
INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948
Scale:
Horizontal - Distance from West Shore, as Indicated
Vertical - Coliforms, MPN per 100 ml, as Indicated
Legend:
Water Works Intake
Bathing Beach
Scale in Miles
Dt-19.0
Dt-17.0e
Dt-14.6w
Dt-9.3e
Dt-3.9
Dt-17.4w
DtER-16.3
Dt-12.0w
DtMo-12.2
Int Bound
Ecorse River
Monguagon Creek
RIVER ROUGE
ECORSE
LA SALLE
FIGHTING ISLAND
GRASSY I.
WYANDOTTE
LINCOLN PARK
ALLEN PARK
RIVERVIEW
TRENTON
GROSSE ILE
GIBRALTAR
AMHERSTBURG
BOIS BLANC
LAKE ERIE
Rouge River
N

Figure 9

107-a

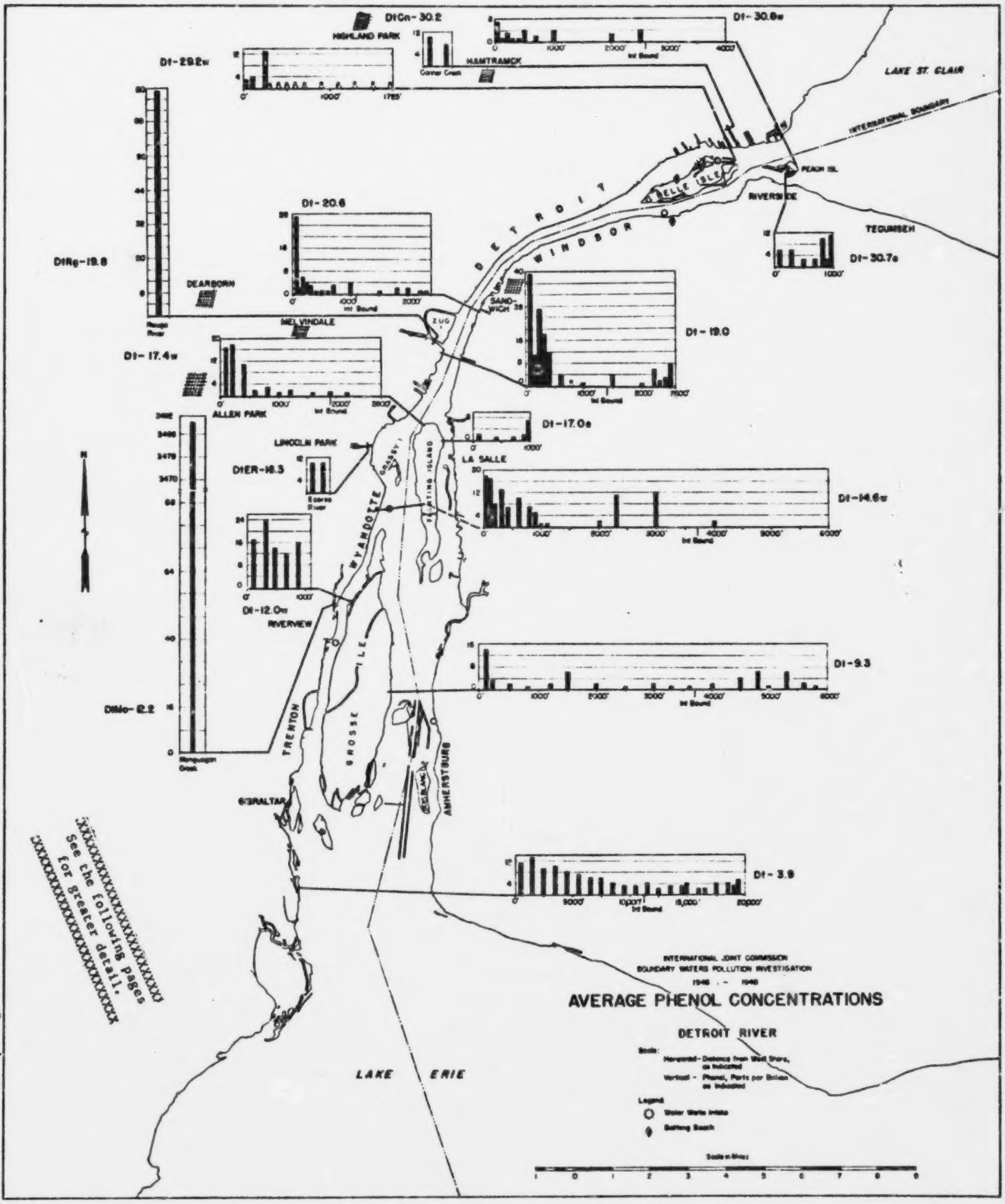

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948
AVERAGE PHENOL CONCENTRATIONS
DETROIT RIVER
Scale:
Horizontal - Distance from West Shore, as Indicated
Vertical - Phenol, Parts per Billion as Indicated
Legend
Water Works Intake
Bathing Beach
Scale in Miles
1 0 1 2 3 4 5 6 7 8 9
LAKE ST. CLAIR
INTERNATIONAL BOUNDARY
PEACH ISL.
BELLE ISLE
RIVERSIDE
TECUMSEH
DETROIT
WINDSOR
SANDWICH
ZUG I.
HIGHLAND PARK
HAMTRAMCK
Conner Creek
DEARBORN
MELVINDALE
ALLEN PARK
LINCOLN PARK
Ecorse River
LA SALLE
GRASSY I.
FIGHTING ISLAND
WYANDOTTE
RIVERVIEW
TRENTON
GROSSE ILE
AMHERSTBURG
GIBRALTAR
Rouge River
Monguagon Creek
LAKE ERIE
N
DtCn-30.2
Dt-30.8w
Dt-29.2w
DtRg-19.8
Dt-20.6
Dt-30.7e
Dt-19.0
Dt-17.4w
Dt-17.0e
DtER-16.3
Dt-14.6w
Dt-12.0w
DtMo-12.2
Dt-9.3
Dt-3.9
Int Bound

Figure 10

XXXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXXX

107-2

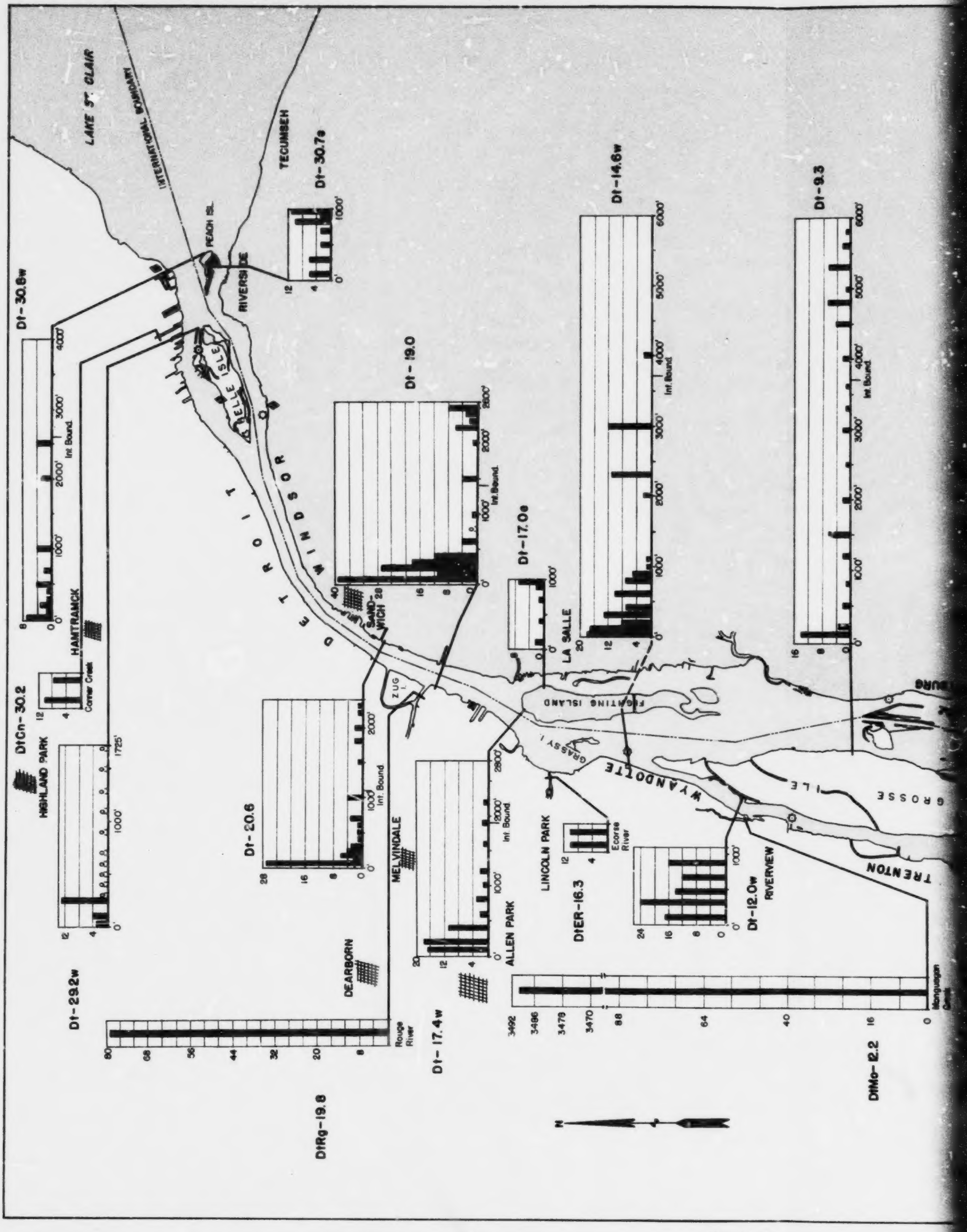
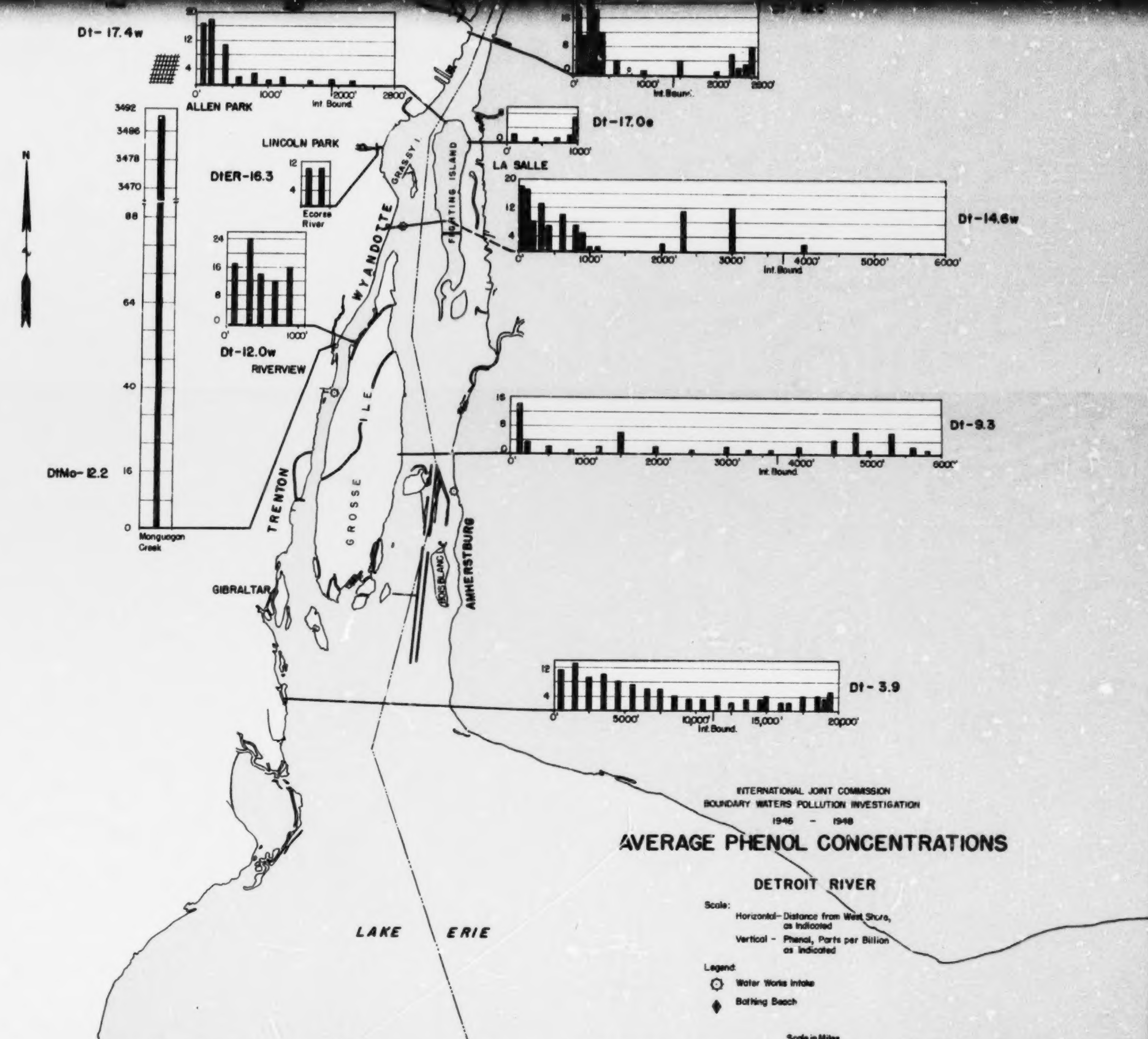

LAKE ST. CLAIR
INTERNATIONAL BOUNDARY
TECUMSEH
PEACH ISL.
RIVERSIDE
BELLE ISLE
DETROIT
WINDSOR
SAND-WICH
ZUG I.
LA SALLE
FIGHTING ISLAND
GRASSY I.
WYANDOTTE
GROSSE ILE
TRENTON
RIVERVIEW
LINCOLN PARK
ALLEN PARK
MELVINDALE
DEARBORN
HIGHLAND PARK
HAMTRAMCK
Conner Creek
Ecorse River
Rouge River
Monguagon Creek
DtCn-30.2
Dt-30.8w
Dt-30.7e
Dt-29.2w
Dt-20.6
Dt-19.0
Dt-17.0e
Dt-17.4w
DtER-16.3
Dt-14.6w
Dt-12.0w
Dt-9.3
DtRg-19.8
DtMo-12.2
Int. Bound.

Figure 10


Dt- 17.4w
ALLEN PARK
Int. Bound.
0'
1000'
2000'
2800'
Dt-17.0e
LA SALLE
LINCOLN PARK
DtER-16.3
Ecorse River
Dt-14.6w
Dt-12.0w
RIVERVIEW
Dt-9.3
DtMo-12.2
Monguagon Creek
3492
3486
3478
3470
88
64
40
16
0
24
20
12
8
4
3000'
4000'
5000'
6000'
Dt- 3.9
5000'
10,000'
15,000'
20,000'
N
GRASSY I.
FIGHTING ISLAND
WYANDOTTE
TRENTON
GROSSE ILE
GIBRALTAR
AMHERSTBURG
BOIS BLANC
LAKE ERIE
Scale in Miles
1 0 1 2 3 4 5 6 7 8 9

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948

AVERAGE PHENOL CONCENTRATIONS

DETROIT RIVER

Scale:
Horizontal - Distance from West Shore, as Indicated
Vertical - Phenol, Parts per Billion as Indicated

Legend:
○ Water Works Intake
♦ Bathing Beach

Figure 10

107-2

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
		0			United States Shore																	
Windmill Point to Head of Peach Island	Dt-30.8W	20	Median	84																		
			Average	....	7.8	7	0.01	0.33	13.0	9.5	0.79	20	7.9	81	0.3	2	....	1	....	....	150	76
			Maximum	>11,000	12	40	0.03	0.65	24.0	13.3	1.50	70	7.9	86	0.6	4	....	2	....	....	160	84
			Minimum	4.5	5.0	0	0	0.15	2.0	4.2	0.20	6	7.8	71	0	1	....	1	....	....	130	68
			No. of Samples	16	15	14	9	6	12	16	15	9	5	5	2	10	....	3	....	4	2	2
		100	Median	93																		
			Average	....	6.7	1	0	0.45	12.5	9.4	0.46	....	7.9	80	....	1	....	....	....	0	....	....
			Maximum	240	8.1	2	0	0.45	15.5	11.4	0.74	....	7.9	84	....	1	....	....	....	0	....	....
			Minimum	49	5.9	0	0	0.45	10.0	5.9	0.20	....	7.8	71	....	1	....	....	....	0	....	....
			No. of Samples	5	5	3	1	1	5	5	4	....	4	4	....	4	....	....	....	1	....	....
		200	Median	49																		
			Average	....	7.5	3	0.003	0.25	13.0	10.0	0.53	19	7.9	81	0.2	2	....	3	....	....	150	84
			Maximum	11,000	12	15	0.02	0.45	23.5	13.7	1.40	70	7.9	85	0.2	5	....	4	....	....	150	84
			Minimum	<2.3	5.4	0	0	0.15	2.0	5.8	0.00	4	7.8	69	0.2	1	....	2	....	....	150	84
			No. of Samples	15	14	12	9	3	12	14	13	8	5	5	1	7	....	2	....	2	1	1
		300	Median	120																		
			Average	....	6.2	1	0	....	13.0	8.5	0.25	35	7.8	79	....	1	....	....	....	0	....	....
			Maximum	1,100	7.1	2	0	....	16.0	10.0	0.30	35	7.9	87	....	1	....	....	....	0	....	....
			Minimum	11	4.8	0	0	....	11.0	5.7	0.20	35	7.7	68	....	0	....	....	....	0	....	....
			No. of Samples	4	4	2	1	....	4	3	2	1	4	4	....	3	....	....	....	1	....	....
		400	Median	49																		
			Average	....	6.1	1	0	....	12.5	9.4	0.39	....	7.9	78	....	1	....	....	....	....	....	....
			Maximum	540	6.9	2	0	....	16.0	11.5	0.76	....	7.9	81	....	1	....	....	....	....	....	....
			Minimum	3.0	5.8	0	0	....	9.5	5.7	0.10	....	7.8	69	....	0	....	....	....	....	....	....
			No. of Samples	5	5	3	1	....	5	5	4	....	4	4	....	4	....	....	....	....	....	....
		500	Median	31																		
			Average	....	6.9	4	0.001	0.28	132.5	9.9	0.66	13	7.8	78	0.5	1	....	3	....	....	140	74
			Maximum	920	11	15	0.01	0.60	24.0	13.9	1.8	35	7.9	83	0.8	2	....	3	....	....	150	64
			Minimum	2	4.8	0	0	0.10	2.0	5.8	0.20	2	7.8	71	0.1	0	....	1	....	....	130	84
			No. of Samples	17	15	14	9	6	12	16	15	9	5	5	2	9	....	3	....	3	2	2

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N₂ ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
Windmill Point to Head of Peach Island (Continued)		700	Median	130																		
			Average	...	5.9	2	0	...	12.5	9.3	0.32	...	7.9	77	...	1	...	...	...	...	...	...
			Maximum	540	6.5	5	0	...	16.0	11.4	0.68	...	7.9	80	...	1	...	...	...	...	...	...
			Minimum	23	5.4	0	0	...	9.5	5.8	0.1	...	7.8	70	...	0	...	...	...	...	...	...
			No. of Samples	5	5	3	1	...	5	5	4	...	4	4	...	4	...	...	...	...	...	...
		1,000	Median	23																		
			Average	...	6.7	4	0.001	0.26	12.5	9.9	6.2	13	7.8	77	0.4	1	...	2	...	0	140	74
			Maximum	240	10	15	0.01	0.6	24.0	13.7	1.4	35	7.9	83	0.7	4	...	3.3	...	0	140	80
			Minimum	3.6	4.4	0	0	0.10	2.0	5.7	0.1	3	7.8	66	0.1	0	...	1	...	0	130	68
			No. of Samples	17	15	9	9	4	12	16	15	9	5	5	5	9	...	4	...	1	2	2
		2,000	Median	11																		
			Average	...	6.8	3	0.002	0.21	11.0	9.9	0.67	14	7.8	78	...	1	...	2	...	...	130	64
			Maximum	130	13	20	0.02	0.50	18.0	13.5	1.70	35	7.9	83	0.6	3.3	...	3.3	...	...	130	68
			Minimum	<1.8	4.0	0	0	0.10	2.0	5.7	0.00	2	7.8	69	0.2	0	...	1	...	...	130	60
			No. of Samples	17	15	14	9	5	12	16	15	9	5	5	2	9	...	4	...	3	2	2
		2,500	Median	7.8																		
			Average	...	6.2	4	0.002	0.21	12.0	10.0	0.57	20	7.9	79	0.5	1	...	3	...	...	170	74
			Maximum	110	11	30	0.02	0.45	23.0	13.6	1.5	47	7.9	84	0.8	2	...	4	...	...	180	74
			Minimum	1.4	4.3	0	0	0.10	2.0	5.8	0.2	7	7.8	69	0.1	1	...	1	...	...	150	74
			No. of Samples	17	15	14	9	5	12	16	15	9	5	5	2	8	...	3	...	3	2	2
		2,600			International Boundary																	
		4,500			Head of Peach Island																	
		0			East Shore Peach Island																	
Peach Island to Canadian Shore at Head of Detroit River	Dt-30.7E	100	Median	15																		
			Average	...	6.3	6	0.001	0.27	12.0	10.0	0.62	15	7.9	77	0.6	1	...	2	...	...	130	65
			Maximum	540	12	40	0.004	0.54	22.5	14.0	1.50	59	7.9	81	1.0	2	...	4	...	...	130	68
			Minimum	2	4.0	0	0	0.10	1.0	5.9	0.10	5	7.8	69	0.1	0	...	1	...	...	130	62
			No. of Samples	15	13	13	7	6	9	14	14	7	4	4	2	10	...	4	...	3	2	2
		300	Median	31																		
			Average	...	5.5	6	0	0.15	12.5	9.3	0.53	5	7.9	77	1.1	2	...	1	...	...	130	62
			Maximum	110	8.0	15	0	0.15	16.0	12.0	0.80	5	7.9	80	1.1	2	...	1	...	...	130	62
			Minimum	4.5	3.7	0	0	0.15	8.5	5.6	0.00	5	7.8	69	1.1	0	...	1	...	...	130	62
			No. of Samples	7	6	5	1	2	4	6	6	1	4	4	1	6	...	2	...	1	1	1

		500	Median	8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	6.3	3	0.001	0.16	12.0	10.0	0.57	12	7.9	78	0.3	1	...	1	...	...	130	76
			Maximum	93	11	15	0.004	0.25	22.5	14.2	2.0	43	7.9	81	0.5	4	...	2	...	...	150	86
			Minimum	2	3.8	0	0	0.10	1.0	5.7	0	3	7.8	70	0	0	...	1	...	...	110	66
			No. of Samples	16	13	13	7	4	9	14	14	7	4	4	2	8	...	4	...	3	2	2
		700	Median	27	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	5.1	3	...	...	14.0	8.6	1.5	...	7.8	77	...	1	...	...	...	...	...	...
			Maximum	46	5.5	5	...	...	16.0	10.1	2.0	...	7.9	80	...	1	...	...	...	...	...	...
			Minimum	7.8	4.5	0	...	...	12.0	5.8	0.1	...	7.7	71	...	0	...	...	...	...	...	...
			No. of Samples	3	3	2	...	...	2	3	2	...	3	3	...	3	...	...	...	...	...	...
		850	Median	17	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	6.4	10	0.001	0.26	11.0	10.3	0.75	14	7.9	80	0.4	2	...	3	...	...	...	...
			Maximum	150	10	80	0.004	0.60	22.5	14.1	2.8	54	7.9	80	0.7	3	...	4	...	...	...	...
			Minimum	<1.8	3.8	0	0	0.10	1.0	7.8	0.2	3	7.9	80	0	1	...	1	...	...	...	...
			No. of Samples	12	10	11	7	5	7	11	11	7	1	1	2	6	...	4	...	3	...	...
		900	Median	17	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	5.1	3	...	...	14.0	8.7	0.2	...	7.9	77	...	1	...	...	...	...	...	...
			Maximum	150	5.2	5	...	...	16.0	10.3	0.3	...	8.0	84	...	1	...	...	...	...	...	...
			Minimum	13	5.1	0	...	...	12.5	6.0	0	...	7.8	70	...	0	...	...	...	...	...	...
			No. of Samples	3	3	2	...	...	2	3	2	...	3	3	...	3	...	...	...	...	...	...
		980	Median	79	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	6.4	11	0	0.32	12.0	9.9	0.56	16	7.9	77	0.6	1	...	2	...	...	140	67
			Maximum	2,400	13	60	0	0.70	22.0	14.2	1.4	59	8.0	82	1.1	3	...	2	...	...	140	76
			Minimum	1.8	3.5	0	0	0.10	2.0	5.8	0	8	7.8	68	0	0	...	0	...	...	130	58
			No. of Samples	15	13	13	7	5	9	14	14	7	3	3	2	8	...	3	...	3	2	2
		1,000			Canadian Shore																	
		0			United States Shore																	
Grayhaven Boat Slip to Peach Island Light	Dt-30.0	100	Median	350	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	6.9	5	0.009	0.32	14.5	9.4	0.40	24	7.9	83	...	1	...	...	...	...	...	...
			Maximum	9,300	9.3	5	0.01	0.32	20.5	10.0	0.50	45	7.9	83	...	1	...	...	...	...	...	...
			Minimum	<91	5.3	5	0	0.32	11.5	8.8	0.29	11	7.8	82	...	1	...	...	...	...	...	...
			No. of Samples	6	6	1	4	1	5	2	2	4	2	2	...	1	...	...	...	...	...	...
		200	Median	70	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	6.7	0	0.001	0.32	14.0	9.9	0.57	20	7.9	80	...	1	...	...	...	...	...	...
			Maximum	11,000	10	0	0.004	0.32	20.5	10.6	0.60	45	7.9	80	...	1	...	...	...	...	...	...
			Minimum	<23	5.0	0	0	0.32	11.5	9.2	0.53	8	7.9	80	...	1	...	...	...	...	...	...
			No. of Samples	6	6	1	4	1	5	2	2	4	1	1	...	1	...	...	...	...	...	...
		400	Median	130	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	6.8	0	0.001	0.30	14.0	9.6	0.41	19	7.9	79	...	1	...	...	...	...	...	...
			Maximum	>1,100	10	0	0.004	0.30	20.5	10.1	0.52	45	7.9	79	...	1	...	...	...	...	...	...
			Minimum	<23	4.8	0	0	0.30	11.5	9.1	0.30	8	7.9	79	...	1	...	...	...	...	...	...
			No. of Samples	6	6	1	4	1	4	2	2	4	1	1	...	1	...	...	...	...	...	...

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
Grayhaven Boat Slip to Peach Island Light (Continued)	Dt-30.0	500	Median	150																		
			Average		6.9	0	0.001	0.30	14.0	9.6	0.37	19	7.9	79		1						
			Maximum	2,400	11	0	0.004	0.30	20.5	10.1	0.44	40	7.9	79		1						
			Minimum	<23	5.0	0	0	0.30	11.0	9.1	0.30	8	7.9	79		1						
			No. of Samples	6	6	1	4	1	4	2	2	4	1	1		1						
		700	Median	230																		
			Average		6.5	0	0.001	0.31	14.0	9.6	0.38	20	7.9	79		1						
			Maximum	930	9.5	0	0.004	0.31	20.0	10.1	0.40	35	7.9	79		1						
			Minimum	<23	4.4	0	0	0.31	11.0	9.1	0.36	8	7.9	79		1						
			No. of Samples	6	6	1	4	1	4	2	2	4	1	1		1						
		1,000	Median	43																		
			Average		6.8	0	0.021		14.0	9.1	0.41	20										
			Maximum	1,100	9.7	0	0.08		20.0	9.1	0.41	35										
			Minimum	<23	5.0	0	0		11.0	9.1	0.41	11										
			No. of Samples	5	5	1	4		4	1	1	4										
		1,300	Median	36																		
			Average		6.9	0	0.001		14.0	9.0	0.36	22										
			Maximum	93	10	0	0.004		20.0	9.0	0.36	35										
			Minimum	<23	5.2	0	0		10.5	9.0	0.36	13										
			No. of Samples	5	5	1	4		4	1	1	4										
		1,600	Median	36																		
			Average		6.5	0	0		14.0	9.0	0.32	20										
			Maximum	230	8.9	0	0		20.0	9.0	0.32	35										
			Minimum	9.1	5.2	0	0		10.5	9.0	0.32	12										
			No. of Samples	5	5	1	4		4	1	1	4										
		2,000	Median	23																		
			Average		6.4	0	0		15.5	9.0	0.33	13										
			Maximum	91	9.0	0	0		20.5	9.0	0.33	20										
			Minimum	<23	5.3	0	0		10.5	9.0	0.33	8										
			No. of Samples	4	4	1	3		3	1	1	3										
		2,700	Median	23																		
			Average		5.9	0	0		14.5	9.3	0.45	18	7.8	83								
			Maximum	36	6.3	0	0		20.5	9.3	0.45	35	7.8	83								
			Minimum	9.1	5.0	0	0		11.0	9.3	0.45	8	7.8	83								

			No. of Samples	5	5	1	4	...	4	1	1	4	1	1	...	...	...	...	...	...	...	...
		3,000			International Boundary																	
		4,900			Canadian Shore																	
Conner Creek at Freud	DtCn-30.2	20	Median	240,000																		
			Average	...	33	10	...	1.38	5.0	7.28	29.4	...	7.4	120	...	6	...	...	...	...	...	...
			Maximum	24,000,000	110	74	...	2.96	17.0	13.7	>84.5	...	7.7	220	...	64	...	...	...	...	...	...
			Minimum	460	5.3	0	...	0.31	0	0	0	...	7.1	50	...	0	...	...	...	...	...	...
			No. of Samples	24	23	22	...	23	24	23	23	...	23	23	...	23	...	...	...	...	...	...
		40	Median	460,000																		
			Average	...	41	7.9	...	1.84	5.3	6.64	48.5	...	7.4	140	...	41	...	...	...	...	...	...
			Maximum	15,000,000	110	74	...	9.07	17.0	13.7	331.5	...	7.9	230	...	256	...	...	...	...	...	...
			Minimum	930	5.9	0	...	0.26	0	0	3.2	...	7.0	46	...	0	...	...	...	...	...	...
			No. of Samples	36	32	30	...	32	33	30	32	...	32	32	...	32	...	...	...	...	...	...
		0			United States Shore																	
Detroit Edison Boat Slip to Detroit Water Intake Boom Lagoon Light, Belle Isle	Dt-29.2W	25	Median	200,000																		
			Average	...	8.7	3	0.78	...	16.0	2.8	>24.6	110	7.7	100	...	...	...	...	...	...	...	...
			Maximum	930,000	12	3	2.30	...	22.0	2.8	>24.6	>200	7.7	100	...	...	...	...	...	...	...	...
			Minimum	24,000	5.8	3	0.006	...	13.0	2.8	>24.6	23	7.7	100	...	...	...	...	...	...	...	...
			No. of Samples	6	6	1	5	...	4	1	1	5	1	1	...	...	...	...	...	...	...	...
		100	Median	93,000																		
			Average	...	8.1	4	0.56	...	15.0	7.8	3.4	91	7.8	88	...	1	...	...	...	...	...	...
			Maximum	1,100,000	11	4	2.0	...	22.0	9.9	>5.6	195	7.9	94	...	1	...	...	...	...	...	...
			Minimum	490	5.8	4	0	...	12.5	5.6	0.7	10	7.7	82	...	1	...	...	...	...	...	...
			No. of Samples	7	7	1	5	...	5	2	2	5	2	2	...	1	...	...	...	...	...	...
		250	Median	910																		
			Average	...	7.3	13	0.32	...	14.5	8.4	6.4	31	7.7	83	...	1	...	...	...	...	...	...
			Maximum	240,000	10	13	1.5	...	21.0	10.1	0.6	65	7.7	83	...	1	...	...	...	...	...	...
			Minimum	78	5.6	13	0	...	11.5	6.7	6.7	9	7.7	83	...	1	...	...	...	...	...	...
			No. of Samples	7	7	1	5	...	5	2	2	5	1	1	...	1	...	...	...	...	...	...
		300	Median	430																		
			Average	...	6.4	0	0.03	0.31	14.5	9.6	0.57	20	7.9	83	...	0	...	...	...	...	...	...
			Maximum	15,000	7.0	0	0.06	0.31	20.5	10.1	0.6	45	7.9	85	...	0	...	...	...	...	...	...
			Minimum	36	5.4	0	0	0.31	11.5	9.0	0.53	8	7.8	81	...	0	...	...	...	...	...	...
			No. of Samples	7	6	1	4	1	5	2	2	4	2	2	...	1	...	...	...	...	...	...
		400	Median	200																		
			Average	...	6.5	0	0	0.30	14.5	9.6	0.32	20	7.9	83	...	0	...	...	...	...	...	...
			Maximum	4,300	8.7	0	0	0.30	20.5	10.0	0.33	45	7.9	85	...	0	...	...	...	...	...	...
			Minimum	<23	5.0	0	0	0.30	11.5	9.1	0.30	8	7.8	80	...	0	...	...	...	...	...	...
			No. of Samples	7	7	1	5	1	5	2	2	5	2	2	...	1	...	...	...	...	...	...

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
Detroit Edison Boat Slip to Detroit Water Intake Boom Lagoon Light, Belle Isle (Continued)	Dt-29.2W	500	Median	93																		
			Average		6.8	0	0	...	14.5	9.1	0.42	19	7.8	83	...	...	...	...	...	...	...	...
			Maximum	4,300	9.5	0	0	...	20.0	9.1	0.42	37	7.8	83	...	...	...	...	...	...	...	...
			Minimum	<23	5.5	0	0	...	11.5	9.1	0.42	7	7.8	83	...	...	...	...	...	...	...	...
			No. of Samples	6	6	1	5	...	3	1	1	5	1	1	...	...	...	...	...	...	...	...
		600	Median	36																		
			Average		7.0	0	0	0.30	14.5	9.7	0.58	13	7.9	80	...	...	...	...	...	...	...	...
			Maximum	240	9.0	0	0	0.30	20.0	10.2	0.70	20	7.9	80	...	0	...	...	...	...	...	...
			Minimum	<23	6.0	0	0	0.30	11.5	9.2	0.46	8	7.9	80	...	0	...	...	...	...	...	...
			No. of Samples	6	6	2	3	1	4	2	2	4	1	1	...	0 1	...	...	...	...	...	...
		700	Median	36																		
			Average		6.8	0	0.004	...	14.5	9.2	0.54	17	7.8	84	...	...	...	...	...	...	...	...
			Maximum	>1,100	9.8	0	0.02	...	20.0	9.2	0.54	35	7.8	84	...	...	...	...	...	...	...	...
			Minimum	9.1	5.4	0	0	...	11.5	9.2	0.54	6	7.8	84	...	...	...	...	...	...	...	...
			No. of Samples	6	6	1	5	...	4	1	1	5	1	1	...	...	...	...	...	...	...	...
		900	Median	36																		
			Average		6.6	0	0	...	14.0	9.2	0.35	17	7.8	84	...	...	...	...	...	...	...	...
			Maximum	>1,100	9.8	0	0	...	20.0	9.2	0.35	35	7.8	84	...	...	...	...	...	...	...	...
			Minimum	7.3	5.4	0	0	...	11.0	9.2	0.35	8	7.8	84	...	...	...	...	...	...	...	...
			No. of Samples	6	6	1	5	...	4	1	1	5	1	1	...	...	...	...	...	...	...	...
		1,100	Median	30																		
			Average		6.2	0	0.004	...	14.0	9.0	0.27	16	7.8	84	...	...	...	...	...	...	...	...
			Maximum	>1,100	6.8	0	0.02	...	20.0	9.0	0.27	35	7.8	84	...	...	...	...	...	...	...	...
			Minimum	7.3	6.0	0	0	...	10.5	9.0	0.27	7	7.8	84	...	...	...	...	...	...	...	...
			No. of Samples	6	5	1	5	...	4	1	1	4	1	1	...	...	...	...	...	...	...	...
		1,300	Median	33																		
			Average		7.0	0	0	...	14.0	9.1	0.40	17	7.9	81	...	...	...	...	...	...	...	...
			Maximum	<460	10.5	0	0	...	20.0	9.1	0.40	35	7.9	81	...	...	...	...	...	...	...	...
			Minimum	<23	5.8	0	0	...	10.5	9.1	0.40	7	7.9	81	...	...	...	...	...	...	...	...
			No. of Samples	6	6	1	5	...	4	1	1	5	1	1	...	...	...	...	...	...	...	...
		1,500	Median	23																		
			Average		6.6	0	0.002	...	14.0	9.1	0.51	22	8.0	86	...	...	...	...	...	...	...	...
			Maximum	460	10	0	0.12	...	20.0	9.1	0.51	42	8.0	86	...	...	...	...	...	...	...	...
			Minimum	23	5.5	0	0	...	10.5	9.1	0.51	8	8.0	86	...	...	...	...	...	...	...	...
			No. of Samples	6	6	1	5	...	4	1	1	5	1	1	...	...	...	...	...	...	...	...

		1,700	Median	36																		
			Average	......	6.5	0	0.004	......	14.0	9.0	0.29	18	7.8	80	......	......	......	......	......	......	......	......
			Maximum	<230	10	0	0.02	......	20.5	9.0	0.29	36	7.8	80	......	......	......	......	......	......	......	......
			Minimum	<23	5.1	0	0	......	10.5	9.0	0.29	3	7.8	80	......	......	......	......	......	......	......	......
			No. of Samples	6	6	1	5	......	4	1	1	5	1	1	......	......	......	......	......	......	......	......
		1,725			West Shore Belle Isle																	
		1,720			Present Water Intake Boom																	
Between Present Detroit Water Intake Boom and Old Intake Structure (400 feet downtream from present Intake)	Dt-29.2W	1,700	Median	380																		
			Average	......	7.0	......	0	......	11	......	......	16	7.8	83	......	......	......	......	......	......	......	......
			Maximum	750	7.2	......	0	......	11	......	......	22	7.8	83	......	......	......	......	......	......	......	......
			Minimum	9.1	6.8	......	0	......	11	......	......	10	7.8	83	......	......	......	......	......	......	......	......
			No. of Samples	2	2	......	2	......	1	......	......	2	1	1	......	......	......	......	......	......	......	......
(800 feet downstream from present Intake)	Dt-29.04W	1,600	Median	300																		
			Average	......	6.2	......	0	......	11	......	......	18	7.8	80	......	......	......	......	......	......	......	......
			Maximum	750	6.4	......	0	......	11	......	......	22	7.8	80	......	......	......	......	......	......	......	......
			Minimum	36	6.0	......	0	......	11	......	......	13	7.8	80	......	......	......	......	......	......	......	......
			No. of Samples	2	2	......	2	......	1	......	......	2	1	1	......	......	......	......	......	......	......	......
(1,200 feet downstream from present Intake)	Dt-28.96W	1,500	Median	480																		
			Average	......	5.4	......	0	......	11	......	......	13	7.8	80	......	......	......	......	......	......	......	......
			Maximum	930	6.4	......	0	......	11	......	......	22	7.8	80	......	......	......	......	......	......	......	......
			Minimum	30	4.4	......	0	......	11	......	......	14	7.8	80	......	......	......	......	......	......	......	......
			No. of Samples	2	2	......	2	......	1	......	......	2	1	1	......	......	......	......	......	......	......	......
(1,600 feet downstream from present Intake)	Dt-28.88W	1,500	Median	230																		
			Average	......	6.2	......	0	......	11	......	......	15	7.8	81	......	......	......	......	......	......	......	......
			Maximum	430	7.2	......	0	......	11	......	......	22	7.8	81	......	......	......	......	......	......	......	......
			Minimum	<23	5.2	......	0	......	11	......	......	8	7.8	81	......	......	......	......	......	......	......	......
			No. of Samples	2	2	......	2	......	1	......	......	2	1	1	......	......	......	......	......	......	......	......
(2,000 feet downstream from present Intake)	Dt-28.70W	1,400	Median	480																		
			Average	......	5.7	......	0	......	11	......	......	24	7.8	82	......	......	......	......	......	......	......	......
			Maximum	930	6.3	......	0	......	11	......	......	35	7.8	82	......	......	......	......	......	......	......	......
			Minimum	23	5.0	......	0	......	11	......	......	12	7.8	82	......	......	......	......	......	......	......	......
			No. of Samples	2	2	......	2	......	1	......	......	2	1	1	......	......	......	......	......	......	......	......
(2,400 feet downstream from present Intake)	Dt-28.72W	1,300	Median	11,000																		
			Average	......	5.0	......	0	......	11	......	......	25	7.8	85	......	......	......	......	......	......	......	......
			Maximum	11,000	5.0	......	0	......	11	......	......	25	7.8	85	......	......	......	......	......	......	......	......
			Minimum	11,000	5.0	......	0	......	11	......	......	25	7.8	85	......	......	......	......	......	......	......	......
			No. of Samples	1	1	......	1	......	1	......	......	1	1	1	......	......	......	......	......	......	......	......

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
Between Present Detroit Water Intake Boom and Old Intake Structure (Continued) (2,800 feet downstream from present Intake)	Dt-28.64W	1,200	Median	5,500																		
			Average		5.6	...	0	...	11	...	...	13	7.8	82	...	...	...	...	...	...	...	...
			Maximum	11,000	6.4	...	0	...	11	...	...	25	7.8	82	...	...	...	...	...	...	...	...
			Minimum	43	4.8	...	0	...	11	...	...	11	7.8	82	...	...	...	...	...	...	...	...
			No. of Samples	2	2	...	2	...	1	...	...	2	1	1	...	...	...	...	...	...	...	...
(3,200 feet downstream from present Intake)			Median	2,300																		
			Average		5.8	...	0.01	...	11	...	...	19	7.9	84	...	...	...	...	...	...	...	...
			Maximum	4,600	6.8	...	0.02	...	11	...	...	25	7.9	84	...	...	...	...	...	...	...	...
			Minimum	73	4.8	...	0	...	11	...	...	13	7.9	84	...	...	...	...	...	...	...	...
			No. of Samples	2	2	...	2	...	1	...	...	2	1	1	...	...	...	...	...	...	...	...
		0			East Shore of Belle Isle, United States																	
Livingstone Light, Belle Isle across Canadian Channel normal to center line of stream	Dt-29.2E	400	Median	33																		
			Average		6.2	0	0	...	16.0	8.9	0.14	8	...	...	...	...	...	...	...	...	...	...
			Maximum	43	6.2	0	0	...	21.0	8.9	0.14	8	...	...	...	...	...	...	...	...	...	...
			Minimum	23	6.2	0	0	...	11	8.9	0.14	8	...	...	...	...	...	...	...	...	...	...
			No. of Samples	2	2	1	1	...	2	1	1	1	...	...	...	...	...	...	...	...	...	...
		1,000	Median	80																		
			Average		6.2	5	0	...	16.0	9.0	0.47	8	...	...	...	...	...	...	...	...	...	...
			Maximum	150	6.4	5	0	...	21.0	9.0	0.47	8	...	...	...	...	...	...	...	...	...	...
			Minimum	11	6.0	5	0	...	11.0	9.0	0.47	8	...	...	...	...	...	...	...	...	...	...
			No. of Samples	2	2	1	1	...	2	1	1	1	...	...	...	...	...	...	...	...	...	...
		1,100			International Boundary																	
		2,000	Median	3,400																		
			Average		6.2	4	0	...	18.0	9.3	0.48	9	...	...	...	...	...	...	...	...	...	...
			Maximum	4,300	6.6	4	0	...	22.0	9.3	0.48	9	...	...	...	...	...	...	...	...	...	...
			Minimum	2,300	5.8	4	0	...	13.0	9.3	0.48	9	...	...	...	...	...	...	...	...	...	...
			No. of Samples	2	2	1	1	...	2	1	1	1	...	...	...	...	...	...	...	...	...	...
		2,400			Canadian Shore																	
		0			United States Shore																	

Water Works Park Coal Dock to Detriot Yacht Club Dock, Belle Isle	Dt-28.4W	100	Median	110,000																		
			Average	....	6.7	....	0.21	....	17.0	....	....	27	....	....	....	....	....	....	....	....	....	....
			Maximum	240,000	7.0	....	0.26	....	22.0	....	....	36	....	....	....	....	....	....	....	....	....	....
			Minimum	46,000	6.2	....	0.16	....	12.0	....	....	19	....	....	....	....	....	....	....	....	....	....
			No. of Samples	3	3	....	2	....	2	....	....	2	....	....	....	....	....	....	....	....	....	....
		200	Median	46,000																		
			Average	....	6.1	....	0.08	....	17.0	....	....	16	....	....	....	....	....	....	....	....	....	....
			Maximum	110,000	6.6	....	0.10	....	21.0	....	....	18	....	....	....	....	....	....	....	....	....	....
			Minimum	9,300	5.7	....	0.06	....	12.0	....	....	13	....	....	....	....	....	....	....	....	....	....
			No. of Samples	3	3	....	2	....	2	....	....	2	....	....	....	....	....	....	....	....	....	....
		300	Median	11,000																		
			Average	....	6.1	....	0.04	....	17.0	....	....	16	....	....	....	....	....	....	....	....	....	....
			Maximum	93,000	6.4	....	0.04	....	21.0	....	....	17	....	....	....	....	....	....	....	....	....	....
			Minimum	9,300	5.8	....	0.04	....	12.0	....	....	15	....	....	....	....	....	....	....	....	....	....
			No. of Samples	3	3	....	2	....	2	....	....	2	....	....	....	....	....	....	....	....	....	....
		400	Median	9,300																		
			Average	....	5.8	....	0	....		....	....	13	....	....	....	....	....	....	....	....	....	....
			Maximum	15,000	6.6	....	0	....	20.5	....	....	14	....	....	....	....	....	....	....	....	....	....
			Minimum	460	5.1	....	0	....	11.5	....	....	11	....	....	....	....	....	....	....	....	....	....
			No. of Samples	3	3	....	2	....	2	....	....	2	....	....	....	....	....	....	....	....	....	....
		700	Median	2,400																		
			Average	....	6.2	....	0	....	15.0	....	....	12	....	....	....	....	....	....	....	....	....	....
			Maximum	>24,000	7.0	....	0	....	20.0	....	....	12	....	....	....	....	....	....	....	....	....	....
			Minimum	23	5.5	....	0	....	11.0	....	....	11	....	....	....	....	....	....	....	....	....	....
			No. of Samples	3	3	....	2	....	2	....	....	2	....	....	....	....	....	....	....	....	....	....
		1,000	Median	43																		
			Average	....	6.7	....	0	....	15.0	....	....	13	....	....	....	....	....	....	....	....	....	....
			Maximum	>24,000	8.0	....	0	....	20.0	....	....	14	....	....	....	....	....	....	....	....	....	....
			Minimum	23	3	....	0	....	11.0	....	....	12	....	....	....	....	....	....	....	....	....	....
			No. of Samples	3	3	....	2	....	2	....	....	2	....	....	....	....	....	....	....	....	....	....
		1,300	Median	93																		
			Average	....	5.9	....	0	....	15.0	....	....	11	....	....	....	....	....	....	....	....	....	....
			Maximum	460	7.2	....	0	....	20.0	....	....	14	....	....	....	....	....	....	....	....	....	....
			Minimum	43	5.2	....	0	....	11.0	....	....	8	....	....	....	....	....	....	....	....	....	....
			No. of Samples	3	3	....	2	....	2	....	....	2	....	....	....	....	....	....	....	....	....	....
		1,500	Median	23																		
			Average	....	5.7	....	0	....	15.0	....	....	11	....	....	....	....	....	....	....	....	....	....
			Maximum	43	6.4	....	0	....	20.0	....	....	13	....	....	....	....	....	....	....	....	....	....
			Minimum	14	4.8	....	0	....	11.0	....	....	8	....	....	....	....	....	....	....	....	....	....
			No. of Samples	3	3	....	2	....	2	....	....	2	....	....	....	....	....	....	....	....	....	....
		1,900			West Side of Belle Isle																	

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
		0			United States Shore, West Shore Detroit River																	
U. S. Engineers Warehouse to Hiram Walker and Sons, Ltd., Canada	Dt-25.7	50	Median	5,400	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	4.5	1	0.05	0.66	2.0	13.2	2.1	12	7.6	80	....	2	Musty	....	....	....	....	....
			Maximum	15,000	6.2	1	16	0.66	2.0	13.8	2.3	14	7.6	80	....	2	Musty	....	....	....	....	....
			Minimum	1,500	2.2	0	0	0.66	2.0	12.3	2.0	9	7.6	80	....	2	Musty	....	....	....	....	....
			No. of Samples	3	3	3	3	1	1	3	3	2	1	1	....	1	....	....	....	....	....	....
		100	Median	1,600	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	6.6	2	0.05	0.53	2.0	13.3	1.5	15	7.6	80	....	2	Petrol	....	....	....	....	....
			Maximum	5,400	7.1	5	0.16	0.53	2.0	13.9	2.2	20	7.6	80	....	2	Petrol	....	....	....	....	....
			Minimum	430	6.0	0	0	0.53	2.0	12.4	0.8	9	7.6	80	....	2	Petrol	....	....	....	....	....
			No. of Samples	3	3	3	3	1	1	3	2	2	1	1	....	1	....	....	....	....	....	....
		300	Median	430	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.8	0	0.03	0.52	1.0	13.3	1.0	16	7.6	80	....	1	Musty	....	....	....	....	....
			Maximum	2,400	7.5	0	0.08	0.52	1.0	13.9	1.5	23	7.6	80	....	1	Musty	....	....	....	....	....
			Minimum	430	3.2	0	0	0.52	1.0	12.4	0.5	9	7.6	80	....	1	Musty	....	....	....	....	....
			No. of Samples	3	3	3	3	1	1	3	3	2	1	1	....	1	....	....	....	....	....	....
		600	Median	60	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	6.4	0	0.02	0.53	1.0	13.3	1.2	13	7.6	80	....	2	Petrol	....	....	....	....	....
			Maximum	75	6.9	0	0.06	0.53	1.0	13.9	1.3	18	7.6	80	....	2	Petrol	....	....	....	....	....
			Minimum	43	5.7	0	0	0.53	1.0	12.3	1.1	8	7.6	80	....	2	Petrol	....	....	....	....	....
			No. of Samples	2	3	3		1	1	3	3	2	1	1	....	1	....	....	....	....	....	....
		1,000	Median	23	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.8	0	0.01	0.56	1.0	13.3	0.80	12	7.6	79	....	1	Petrol	....	....	....	....	....
			Maximum	130	6.4	0	0.04	0.56	1.0	13.8	0.70	16	7.6	79	....	1	Petrol	....	....	....	....	....
			Minimum	23	4.9	0	0	0.56	1.0	12.2	0.50	16	7.6	79	....	1	Petrol	....	....	....	....	....
			No. of Samples	3	3	3	3	1	1	3	3	2	1	1	....	1	....	....	....	....	....	....
		1,900			International Boundary																	
		2,000	Median	43	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	5.9	0	0.01	0.56	1.0	13.2	0.83	12	7.6	80	....	1	Musty	....	....	....	....	....
			Maximum	68	6.3	0	0.04	0.56	1.0	14.0	1.20	16	7.6	80	....	1	Musty	....	....	....	....	....
			Minimum	7.3	5.2	0	0	0.56	1.0	12.0	0.37	8	7.6	80	....	1	Musty	....	....	....	....	....
			No. of Samples	3	3	3	3	1	1	3	3	2	1	1	....	1	....	....	....	....	....	....
		2,600	Median	68	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	4.9	0	0.02	0.60	1.0	13.4	1.1	12	7.6	77	....	2	Petrol	....	....	....	....	....
			Maximum	93	5.3	0	0.06	0.60	1.0	14.0	1.40	16	7.6	77	....	2	Petrol	....	....	....	....	....

			Minimum	23	4 4	0	0	0.60	1.0	12.4	0.80	8	7.6	77	....	2	Petrol	....	....	....	....	....
			No. of Samples	3	3	3	3	1	1	3	3	2	1	1	....	1	....	....	....	....	....	....
		3,200	Median	60																		
			Average	....	6.1	0	0	....	1.0	13.2	0.90	13	....	....	....	....	....	....	....	....	....	....
			Maximum	93	6.3	0	0	....	1.0	14.1	1.30	13	....	....	....	....	....	....	....	....	....	....
			Minimum	<36	5.8	0	0	....	1.0	12.3	0.49	13	....	....	....	....	....	....	....	....	....	....
			No. of Samples	2	2	2	2	....	1	2	2	2	....	....	....	....	....	....	....	....	....	....
		3,400	Median	170																		
			Average	....	5.9	0	0	....	2.0	13.3	0.66	13	....	....	....	....	....	....	....	....	....	....
			Maximum	230	6.1	0	0	....	2.0	14.2	0.84	14	....	....	....	....	....	....	....	....	....	....
			Minimum	93	5.7	0	0	....	2.0	12.4	0.47	12	....	....	....	....	....	....	....	....	....	....
			No. of Samples	2	2	2	2	....	1	2	2	2	....	....	....	....	....	....	....	....	....	....
		3,450			East	Shore,	Canada															
		0			Unite	d Stat	es Shore															
Foot of 12th Street across to Windsor Dock Company, Canada	Dt-23.1	100	Median	4,300													Earthy					
			Average	....	9.1	0	0	....	7.0	10.6	0.91	20	7.8	83	....	1	....	....	....	....	....	....
			Maximum	14,000	13	0	0	....	12.0	13.9	1.90	32	7.8	83	....	1	....	....	....	....	....	....
			Minimum	2,900	6.7	0	0	....	2.0	5.8	0.00	8	7.8	83	....	1	....	....	....	....	....	....
			No. of Samples	3	3	2	2	....	2	3	3	2	1	1	....	1	....	....	....	....	....	....
		200	Median	210													Earthy					
			Average	....	6.8	0	0	....	7.0	10.7	0.28	18	7.8	82	....	1	....	....	....	....	....	....
			Maximum	430	7.2	0	0	....	12.0	14.0	1.70	27	7.8	82	....	1	....	....	....	....	....	....
			Minimum	78	6.5	0	0	....	2.0	5.8	0.00	8	7.8	82	....	1	....	....	....	....	....	....
			No. of Samples	3	3	2	2	....	2	3	3	2	1	1	....	1	....	....	....	....	....	....
		400	Median	130													0					
			Average	....	6.6	0	0	....	7.0	10.7	0.94	14	7.8	81	....	0	....	....	....	....	....	....
			Maximum	210	7.0	0	0	....	12.0	14.0	2.10	19	7.8	81	....	0	....	....	....	....	....	....
			Minimum	93	6.1	0	0	....	1.0	5.8	0.00	9	7.8	81	....	0	....	....	....	....	....	....
			No. of Samples	3	3	2	2	....	2	3	3	2	1	1	....	1	....	....	....	....	....	....
		800	Median	93													0					
			Average	....	5.7	0	0	....	7.0	10.7	0.66	16	7.8	80	....	0	....	....	....	....	....	....
			Maximum	220	7.0	0	0	....	12.5	13.9	0	23	7.8	80	....	0	....	....	....	....	....	....
			Minimum	43	4.7	0	0	....	1.0	5.9	0	8	7.8	80	....	0	....	....	....	....	....	....
			No. of Samples	3	3	2	2	....	2	3	3	2	1	1	....	1	....	....	....	....	....	....
		1,000			Inter	nation	al Boun	dary														
		1,100	Median	93													0					
			Average	....	5.6	0	0	....	7.0	10.5	0.55	11	7.9	81	....	0	....	....	....	....	....	....
			Maximum	170	6.7	0	0	....	12.5	13.7	1.10	15	7.9	81	....	0	....	....	....	....	....	....
			Minimum	9.1	4.4	0	0	....	1.0	5.7	0.00	7	7.9	81	....	0	....	....	....	....	....	....
			No. of Samples	3	3	2	2	....	2	3	3	2	1	1	....	1	....	....	....	....	....	....

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
Foot of 12th Street across to Windsor Dock Company, Canada (Continued)	Dt-23.1	1,700	Median	43																		
			Average		5.0	0	0		7.0	10.7	0.69	11	7.8	80		0	0					
			Maximum	240	5.7	0	0		12.5	14.0	0.76	17	7.8	80		0						
			Minimum	<18	4.1	0	0		1.0	5.8	0.00	5	7.8	80		0						
			No. of Samples	3	3	2	2		2	3	3	2	1	1		1						
		2,100	Median	91																		
			Average		5.7	0	0		7.0	10.8	0.65	12	7.9	82		0	0					
			Maximum	490	6.9	0	0		13.0	14.1	1.10	15	7.9	82		0						
			Minimum	43	4.9	0	0		1.0	5.8	0.00	8	7.9	82		0						
			No. of Samples	3	3	2	2		2	3	3	2	1	1		1						
		2,200	Median	1,500																		
			Average		5.4	0	0		7.0	10.7	0.63	15	7.9	81		1	Earthy					
			Maximum	24,000	6.1	0	0		13.0	14.0	1.20	18	7.9	81		1						
			Minimum	430	4.6	0	0		1.0	5.8	0.00	11	7.9	81		1						
			No. of Samples	3	3	2	2		2	3	3	2	1	1		1						
		2,300			East Shore, Canada																	
		0			United States Shore																	
Above Rouge River from Delray Detroit Edison Dock to Canadian Industries, Ltd., Dock	Dt-20.6	5	Median	24,000																		
			Average		7.2	2			14.0	8.3	0.20		7.8	82		1.3						
			Maximum	54,000	7.8	7			16.0	9.8	0.40		7.8	83		2						
			Minimum	11,000	6.3	0			12.5	5.7	0		7.8	80		1						
			No. of Samples	3	3	3			3	3	2		3	3		3						
		20	Median	24,000																		
			Average		7.3	27	0.03	0.32	13.5	9.9	0.95	15	7.8	82	0	6		5			140	70
			Maximum	110,000	11	450	0.44	0.5	25.0	13.9	2.0	31	7.8	83	0	15		5			140	70
			Minimum	490	3.0	0	0	0.2	0	7.7	0.32	5	7.7	81	0	1		4			140	70
			No. of Samples	20	20	21	16	4	17	18	18	13	2	2	1	4		2			1	1
		50	Median	15,000																		
			Average		7.0	2			14.0	8.4	0.3		7.8	83		1						
			Maximum	35,000	7.6	5			16.0	10.0	0.5		7.8	87		1						
			Minimum	3,300	5.9	0			12.5	5.9	0		7.8	83		0						
			No. of Samples	3	3	3			3	3	2		3	3		3						

100	Median	15,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Average	...	7.7	6	0.006	0.23	13.5	9.8	0.88	17	7.8	81	0.6	2	...	2	...	...	150	78
	Maximum	240,000	15	90	0.04	0.26	25.0	14.0	4.00	31	7.8	83	1.3	4	...	4	...	...	160	73
	Minimum	2,300	5.8	0	0	0.20	0	5.80	0	2.6	7.8	79	0	0	...	1	...	...	130	70
	No. of Samples	26	25	26	16	5	21	23	23	14	5	5	2	9	...	4	...	2	2	2
200	Median	12,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Average	...	7.1	4	0.004	0.23	13.5	9.9	0.81	14	7.8	81	0.2	1	...	1	...	...	160	88
	Maximum	110,000	12	60	0.04	0.25	25.0	14.1	4.0	33	7.9	83	0.2	2	...	1	...	...	160	88
	Minimum	91	5.0	0	0	0.20	0	5.70	0	4	7.7	80	0.2	1	...	1	...	...	160	88
	No. of Samples	24	24	24	16	2	21	21	21	13	5	5	1	7	...	7	...	1	1	1
300	Median	2,400	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Average	...	7.0	3	0.05	0.20	13.0	10.0	0.77	13	7.8	81	0.4	1	...	2	...	...	140	76
	Maximum	>24,000	12	25	0.50	0.31	24.5	14.0	3.60	32	7.8	83	0.7	3	...	4	...	...	150	90
	Minimum	91	4.8	0	0	0.15	0	5.7	0	3	7.8	80	0	0	...	1	...	...	130	62
	No. of Samples	26	25	26	16	4	21	23	23	14	5	5	2	9	...	4	...	2	2	2
400	Median	240	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Average	...	6.6	1	0	0.23	13.0	10.0	0.47	13	7.8	80	0	1	...	2	...	...	160	98
	Maximum	9,200	13	10	0	0.33	24.5	14.0	1.3	32	7.9	81	0	5	...	3	...	...	160	98
	Minimum	36	4.4	0	0	0.15	0	5.8	0	3	7.8	80	0	0	...	1	...	...	160	98
	No. of Samples	24	24	24	16	3	21	21	21	13	5	5	1	7	...	2	...	1	1	1
500	Median	240	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Average	...	6.9	1	0.03	0.21	11.0	9.9	0.47	13	7.8	80	0.2	1	...	2	...	...	150	73
	Maximum	2,400	12	8	0.38	0.31	24.5	13.9	1.40	28	7.9	80	0.4	3	...	4	...	...	150	80
	Minimum	36	4.8	0	0	0.15	0	5.8	0.00	3	7.7	80	0	0	...	1	...	...	140	66
	No. of Samples	22	22	24	14	5	18	21	21	12	5	5	2	9	...	4	...	2	2	2
600	Median	93	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Average	...	6.4	1	0.003	0.16	13.0	9.9	0.47	12	7.8	80	0.3	1	...	1	...	...	150	65
	Maximum	460	12	10	0.04	0.33	24.5	14.0	1.20	23	7.9	81	0.5	2	...	4	...	...	150	86
	Minimum	36	4.2	0	0	0.02	0	5.7	0.00	2	7.7	79	0	0	...	1	...	...	140	44
	No. of Samples	23	23	24	14	5	19	21	21	12	5	5	2	8	...	4	...	2	2	2
700	Median	240	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Average	...	5.2	3	0.06	0.31	10.5	10.3	0.47	...	7.8	80	...	0	...	...	...	...	...	...
	Maximum	240	5.7	8	0.06	0.32	15.5	12.4	0.85	...	7.9	80	...	0	...	...	...	...	...	...
	Minimum	49	4.6	0	0.06	0.31	5.5	5.8	0	...	7.7	79	...	0	...	...	...	...	...	...
	No. of Samples	7	7	7	1	1	7	7	6	...	5	5	...	4	...	...	...	...	...	...
1,000	Median	93	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Average	...	6.2	4	0.006	0.20	13.0	10.0	0.56	14	7.8	79	0.7	...	...	1	...	...	150	79
	Maximum	750	12	40	0.08	0.30	24.5	14.2	1.8	25	7.9	80	1.1	3	...	2	...	...	150	88
	Minimum	15	4.2	0	0	0.1	0	5.78	0.00	3	7.6	78	0.2	0	...	1	...	...	140	70
	No. of Samples	23	23	24	14	5	19	21	21	12	5	5	2	8	...	4	...	2	2	2
1,100			International Boundary																	

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
Above Rouge River from Delray Detroit Edison Dock to Canadian Industries, Ltd., Dock (Continued)	Dt-20.6	1,500	Median	180	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	6.2	1	0	0.18	13.0	9.9	0.58	13	7.8	79	0.4	2	....	1	....	....	140	70
			Maximum	5,400	12	12	0	0.32	24.5	14.3	1.30	23	7.8	81	0.8	3	....	1	....	....	140	74
			Minimum	23	4.2	0	0	0.1	0	5.8	0.16	3	7.8	78	0	0	....	1	....	....	140	60
			No. of Samples	24	21	23	13	5	18	21	21	12	5	5	2	8	....	3	....	2	2	2
		1,800	Median	930	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	6.1	2	0.03	0.18	13.0	9.9	0.56	16	7.8	80	0.2	1	....	1	....	....	140	69
			Maximum	11,000	10	10	0.44	0.33	24.5	14.1	1.4	39	7.8	81	0.4	3	....	1	....	....	140	78
			Minimum	33	4.1	0	0	0.10	0	5.9	0	2	7.8	78	0	1	....	1	....	....	130	60
			No. of Samples	23	22	24	14	5	18	21	21	12	5	5	2	9	....	3	....	1	2	2
		2,000	Median	2,400	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	6.0	2	0	0.19	13.5	9.9	0.84	17	7.7	81	0.5	1	....	1	....	....	130	71
			Maximum	24,000	11	10	0	0.31	24.5	14.3	4.80	42	7.8	83	0.9	3	....	1	....	....	150	76
			Minimum	230	4.1	0	0	0.1	0	5.8	0.00	2	7.4	80	0	1	....	1	....	....	110	66
			No. of Samples	24	22	24	14	5	18	21	21	12	5	5	2	9	....	3	....	2	2	2
		2,200	Median	9,200	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	6.4	1	0.01	0.19	13.5	9.8	0.70	18	7.8	81	0.4	1	....	3	....	....	150	68
			Maximum	46,000	9.4	8	0.16	0.26	24.5	14.2	1.5	50	7.9	83	0.7	6.7	....	6.7	....	....	160	74
			Minimum	2,300	4.1	0	0	0.15	0	5.9	0	3	7.7	79	0	0	....	1	....	....	130	62
			No. of Samples	24	22	24	11	5	18	21	21	12	5	5	2	9	....	3	....	3	2	2
		2,300	Median	8,200	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	8.9	1	0	0.17	13.5	9.8	1.25	18	7.8	81	0.1	1	....	1	....	....	160	80
			Maximum	43,000	15	10	0	0.26	24.5	14.2	1.60	43	7.9	82	0.3	2	....	1	....	....	170	84
			Minimum	1,100	5.5	0	0	0.1	0	5.8	0.00	2	7.7	80	0	1	....	1	....	....	150	76
			No. of Samples	23	22	24	14	5	18	21	21	12	5	5	2	9	....	3	....	2	2	2
		2,400			Canadian Shore																	
Rouge River (New Channel) at D.T.I. Railroad Bridge	DtRg-19.8	70	Median	43,000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	29	79	0.57	2.4	3.0	11.4	11.1	28	7.4	97	....	19	....	....	....	....	....	....
			Maximum	930,000	76	260	1.1	3.7	16.0	13.7	21.1	68	8.2	120	....	64	....	....	....	....	....	....
			Minimum	9,100	17	0	0.08	1.6	0	10.3	3.85	8	7.1	72	....	2	....	....	....	....	....	....
			No. of Samples	22	24	25	25	4	25	23	23	20	24	23	....	19	....	....	....	....	....	....
		0			United States Shore																	

Below Rouge River from War Surplus Depot to Canadian Bridge Co., Ltd., Boat Slip	Dt-19.0	100	Median	93,000																		
			Average	....	47	39	0.22	0.84	13.5	8.2	3.8	26	7.8	85	0.93	3.5	....	4.5	....	....	300	150
			Maximum	1,100,000	66	360	0.56	1.2	24.5	13.2	8.1	178	7.9	89	3.9	6.7	....	6.7	....	....	330	160
			Minimum	23,000	26	4	0	0.10	1.0	4.40	0.3	4.7	7.7	82	0	1	....	3	....	....	270	140
			No. of Samples	31	30	32	19	13	25	32	32	17	8	8	10	20	....	4	....	4	3	3
		150	Median	54,000																		
			Average	....	35	11	....	....	14.0	5.75	2.7	....	7.8	83	....	1	....	....	....	....	....	....
			Maximum	130,000	39	12	....	....	16.5	7.48	4.0	....	7.9	85	....	2	....	....	....	....	....	....
			Minimum	14,000	32	10	....	....	12.5	4.25	0.6	....	7.7	82	....	1	....	....	....	....	....	....
			No. of Samples	3	3	3	....	....	3	3	3	....	3	3	....	3	....	....	....	....	....	....
		200	Median	39,000																		
			Average	....	32	27	0.41	0.70	8.5	9.1	4.3	2.3	7.8	84	0.5	1.7	....	1.5	....	....	240	110
			Maximum	460,000	52	80	0.56	1.1	16.5	12.3	7.2	13	7.9	87	0.7	4	....	2	....	....	200	120
			Minimum	2,300	17	0	0.26	0.16	6.0	4.9	0.92	3.2	7.7	82	0.2	1	....	1	....	....	190	94
			No. of Samples	11	12	11	2	4	10	11	11	2	8	8	2	10	....	2	....	2	2	2
		300	Median	46,000																		
			Average	....	29	18	0.26	0.58	13.5	8.7	3.7	17	7.8	81	1.1	2.4	....	2	....	....	210	93
			Maximum	460,000	51	80	0.46	0.85	25.0	13.6	7.2	45	8.0	84	3.0	5	....	3	....	....	230	100
			Minimum	2,300	2.1	0	0	0.18	1	5.2	0.4	4.9	7.6	76	0	0	....	1	....	....	190	86
			No. of Samples	31	30	32	19	10	19	32	32	17	8	8	8	14	....	4	....	4	3	3
		400	Median	9,200																		
			Average	....	18	12	0.12	0.37	13.0	9.8	2.0	14	7.8	81	0.34	2	....	2	....	....	170	76
			Maximum	460,000	35	120	0.46	0.7	24.5	13.6	6.7	33	7.9	83	3.8	5	....	4	....	....	200	94
			Minimum	<300	5.3	0	0	0	1.0	5.40	0	4.3	7.7	79	0	0	....	1	....	....	140	64
			No. of Samples	31	30	32	19	11	25	32	32	17	8	8	9	18	....	4	....	4	3	3
		600	Median	3,000																		
			Average	....	11	4	0.02	0.26	13.0	9.8	1.2	14	7.9	80	0.8	1	....	1	....	....	150	67
			Maximum	240,000	29	20	0.26	0.55	24.5	13.9	5.5	41	8.0	82	2.8	3	....	2	....	....	170	78
			Minimum	73	4.2	0	0	0.1	0	5.50	0.1	2.7	7.8	79	0	0	....	1	....	....	140	62
			No. of Samples	30	30	32	19	10	25	32	32	17	8	8	5	14	....	4	....	4	3	3
		800	Median	500																		
			Average	....	7.7	0	0.01	0.22	10.0	10.2	1.16	....	7.9	81	....	0.3	....	....	....	....	....	....
			Maximum	>1,100	20	0	0.02	0.27	16.5	12.6	3.70	....	7.9	82	....	1	....	....	....	....	....	....
			Minimum	23	4.0	0	0	0.14	5.5	5.60	0.05	....	7.8	79	....	0	....	....	....	....	....	....
			No. of Samples	10	10	10	2	3	10	10	10	....	8	8	....	8	....	....	....	....	....	....
		1,000	Median	2,400																		
			Average	....	7.1	1	0.001	0.33	12.5	10.9	0.66	12	7.9	80	0.2	1.1	....	1	....	....	150	75
			Maximum	24,000	12	6	0.02	0.6	24.0	13.9	2.00	33	7.9	81	0.5	3	....	1	....	....	160	88
			Minimum	20	3.8	0	0	0.1	0	5.7	0	2.9	7.8	79	0	0	....	1	....	....	140	58
			No. of Samples	31	30	32	19	13	25	32	32	17	8	8	3	20	....	4	....	4	3	3
		1,400	....	....	International Boundary																	

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold: Raw		Threshold Odor, Cold: Chlorinated		Taste	Total Solids ppm	
																No.	Nature	No.	Nature		Total	Volatile
Below Rouge River from War Surplus Depot to Canadian Bridge Co., Ltd., Boat Slip (Continued)	Dt-19.0	1,500	Median	77																		
			Average		7.0	4	0.001	0.20	12.0	9.9	0.66	13	7.9	81	0.2	1.5		3			150	66
			Maximum	11,000	15	65	0.02	0.33	24.0	14.0	4.2	33	8.0	82	0.5	10		5			160	78
			Minimum	15	4.1	0	0	0.1	0	5.7	0	2.6	7.8	79	0	0		1			140	60
			No. of Samples	26	26	27	14	7	22	28	28	13	8	8	3	11		3		3	3	3
		2,000	Median	330																		
			Average		5.5	1	0.01	0.38	10.0	10 3	0.9		7.8	80		0.1						
			Maximum	11,000	6.8	5	0.02	0.65	15.5	13.0	4.2		7.9	82		1						
			Minimum	15	4.3	0	0	0.21	5.0	5.6	0		7.7	78		0						
			No. of Samples	10	10	10	2	5	10	10	10		8	8		10						
		2,200	Median	930																		
			Average		6.9	6	0.004	0.28	12.0	9.8	0.79	14	7.8	81	0.1	2		3			150	64
			Maximum	24,000	11	140	0.02	0.55	24.0	14.2	4.1	30	8.0	85	0.1	10		5			160	80
			Minimum	23	4.5	0	0	0.10	0	5.60	0	2.4	7.7	79	0	0		1			140	52
			No. of Samples	28	27	29	16	11	22	29	29	14	8	8	3	17		4		3	3	3
		2,300	Median	11,000																		
			Average		6.7	2			13.5	7.0	1.0		8.0	83		0.7						
			Maximum	13,000	7.5	6			15.5	9.5	3.0		8.0	84		1						
			Minimum	9,200	5.4	0			12.5	5.6	0		7.9	81		0						
			No. of Samples	3	3	3			3	3	3		3	3		3						
		2,400	Median	2,700																		
			Average		8.9	3	0.02	0.29	12.0	9.5	0.84	15	7.9	81	0.9	1		1			150	55
			Maximum	24,000	26	70	0.28	0.80	24.0	14.2	4.5	28	8.0	85	2.5	5		2			160	84
			Minimum	73	4.4	0	0	0.1	0	5.6	0	2.4	7.7	79	0	0		1			120	24
			No. of Samples	28	27	29	16	10	22	30	29	14	8	8	3	15		5		5	3	3
		2,500	Median	4,600																		
			Average		13	8	1	0.30	12.0	9.9	1.02	16	7.9	82	0.2	1.3		3			180	71
			Maximum	46,000	27	100	0.20	0.6	24.0	14.2	4.3	32	8.0	83	0.6	6.7		3			220	90
			Minimum	230	5.3	0	0	0.1	0	5.8	0	2.9	7.7	78	0	0		1			130	38
			No. of Samples	27	26	26	16	10	21	28	28	14	8	8	3	18		5		5	3	3
		2,600			Canadian Shore																	
		0			United States Shore																	
Ecorse Light to Head of Fighting Island	Dt-17.4W	100	Median	43,000																		
			Average		39	17	0.23	0.87	13.5	8.5	2.9	47	7.6	78	1.1	3.2		4			280	120
			Maximum	1,100,000	53	44	0.46	2.40	26.5	13.0	4.7	400	7.9	83	3.1	6.7		10.0			330	140

	Minimum	15,000	32	0	0.04	0.3	1.0	5.4	1.4	4.0	7.0	56	0	0	....	1	....	....	210	110
	No. of Samples	29	27	28	18	5	23	28	28	16	6	6	11	10	....	5	....	5	3	3
200	Median	43,000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	Average	....	33	18	0.22	0.58	9.0	10.9	3.3	....	7.9	83	....	1	....	....	....	....	....	....
	Maximum	170,000	41	40	0.34	0.64	14.5	13.0	5.4	....	8.0	85	....	1	....	....	....	....	....	....
	Minimum	7,300	28	6	0.14	0.51	2.5	8.4	1.3	....	7.6	81	....	0	....	....	....	....	....	....
	No. of Samples	9	9	9	3	2	9	8	8	....	6	6	....	6	....	....	....	....	....	....
400	Median	43,000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	Average	....	28	11	0.13	0.32	13.0	9.4	2.5	19	7.8	82	1.2	2.2	....	1.8	....	....	230	120
	Maximum	1,100,000	39	25	0.36	0.41	25.5	13.4	5.0	37	8.0	83	4.6	6.7	....	3	....	....	260	140
	Minimum	3,600	12	0	0	0.25	1.0	6.1	1.2	4.6	7.8	81	0	0	....	0	....	....	190	100
	No. of Samples	29	27	27	18	7	23	28	28	16	6	6	11	11	....	5	....	4	3	3
600	Median	6,800	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	Average	....	13	2	0.05	0.27	8.5	11.5	1.6	....	7.8	81	1.9	0.5	....	....	....	....	....	....
	Maximum	46,000	21	8	0.08	0.29	14.0	13.2	3.8	....	8.0	83	1.9	1	....	....	....	....	....	....
	Minimum	2,300	9.1	0	0	0.24	0.5	9.05	0.5	....	7.7	80	1.9	0	....	....	....	....	....	....
	No. of Samples	9	9	9	3	3	9	8	8	....	6	6	1	6	....	....	....	....	....	....
800	Median	4,600	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	Average	....	13	3	0.04	0.27	12.5	9.7	1.5	13	7.8	80	1.0	1.6	....	2	....	....	180	83
	Maximum	>2,400,000	37	20	0.36	0.31	25.0	13.7	7.8	34	7.9	80	2.9	5	....	4	....	....	200	110
	Minimum	330	5.6	0	0	0.2	0.5	2.0	0.6	4.3	7.6	79	0	0	....	1	....	....	160	64
	No. of Samples	29	27	28	18	7	23	28	28	16	6	6	10	11	....	4	....	4	3	3
1,000	Median	350	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	Average	....	6.0	1	0.01	0.27	8.0	11.8	1.3	....	7.8	80	....	0.5	....	....	....	....	....	....
	Maximum	4,600	7.2	5	0.02	0.31	14.0	13.2	4.6	....	7.9	82	....	1	....	....	....	....	....	....
	Minimum	36	5.1	0	0	0.23	0.5	9.92	0.4	....	7.7	79	....	0	....	....	....	....	....	....
	No. of Samples	9	9	9	3	3	9	8	8	....	6	6	....	6	....	....	....	....	....	....
1,200	Median	920	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	Average	....	7.8	2	0.005	0.27	12.5	10.7	0.84	12	7.8	79	0.8	1.6	....	1.3	....	....	150	67
	Maximum	240,000	16	13	0.06	0.50	24.5	13.8	4.6	28	8.0	81	1.7	6.7	....	2	....	....	170	80
	Minimum	23	4.0	0	0	0.15	0	7.8	0.12	2.4	7.7	78	0	0	....	1	....	....	130	54
	No. of Samples	29	26	27	17	7	22	27	27	16	6	6	3	11	....	4	....	2	3	3
1,400	Median	580	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	Average	....	4.6	0	....	....	13.5	9.9	4.5	....	7.9	80	....	0	....	....	....	....	....	....
	Maximum	620	5.2	0	....	....	13.5	9.9	4.5	....	8.0	82	....	0	....	....	....	....	....	....
	Minimum	540	4.0	0	....	....	13.0	9.9	4.5	....	7.8	78	....	0	....	....	....	....	....	....
	No. of Samples	2	2	2	....	....	2	1	1	....	2	2	....	2	....	....	....	....	....	....
1,600	Median	210	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	Average	....	7.2	1	0.001	0.30	12.5	10.1	0.71	12	7.8	80	1.1	1	....	1	....	....	160	67
	Maximum	>24,000	14	10	0.02	0.50	24.5	14.0	4.6	25	7.9	81	2.8	4	....	2	....	....	170	78
	Minimum	9.1	4.2	0	0	0.10	0	8.0	0.14	2.4	7.7	78	0	0	....	1	....	....	150	60
	No. of Samples	29	27	28	18	8	23	28	28	16	6	6	3	11	....	4	....	1	3	3

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
Ecorse Light to Head of Fighting Island (Continued)	Dt-17.4W	1,900			International Boundary																	
		1,900	Median	240																		
			Average	...	6.9	1.4	0.005	0.26	12.5	10.0	0.80	24	7.8	80	0.4	3.7	...	6.0	...	...	160	71
			Maximum	110,000	12	10	0.04	0.5	24.5	14.1	4.6	200	7.9	81	0.8	26.7	...	20.0	...	...	170	80
			Minimum	23	4.6	0	0	0.15	0	8.0	0.06	2.5	7.8	78	0	0	...	1	...	...	140	66
			No. of Samples	29	27	28	18	7	23	28	28	16	6	6	8	11	...	4	...	2	3	3
		2,200	Median	390																		
			Average	...	6.5	1	0.01	0.24	12.4	10.2	0.97	18	7.8	80	0.1	1	...	1	...	...	160	71
			Maximum	4,600	10	12	0.14	0.4	24.5	14.2	6.7	110	7.9	83	0.4	3	...	2	...	...	160	82
			Minimum	33	4.3	0	0	0.1	0	7.8	0.1	2.7	7.8	78	0	0	...	1	...	...	160	60
			No. of Samples	29	27	28	18	7	23	28	28	16	6	6	3	10	...	4	...	2	3	3
		2,800			West Shore of Fighting Island																	
		0			East Shore of Fighting Island																	
Fighting Island to LaSalle Oil and Coal Co. Boat Slip on Canadian Shore	Dt-17.0E	100	Median	1,400																		
			Average	...	6.9	2	0.007	0.21	12.5	10.0	0.76	16	7.8	80	0.4	1.4	...	1.5	...	...	150	63
			Maximum	15,000	20	12	0.06	0.30	24.5	14.2	4.3	65	8.0	84	0.9	3	...	3	...	...	180	96
			Minimum	150	4.5	0	0	0.1	0	8.0	0.06	2.4	7.7	78	0	0	...	1	...	...	110	38
			No. of Samples	28	26	27	17	7	22	27	27	15	6	6	3	11	4	4	...	2	3	3
		400	Median	2,400																		
			Average	...	6.1	1	0.01	...	8.5	11.6	1.39	...	7.8	81	...	1	...	...	...	...	...	...
			Maximum	4,600	8.8	5	0.04	...	16.0	13.6	4.6	...	8.0	84	...	2	...	...	...	...	...	...
			Minimum	750	4.1	0	0	...	0.5	9.60	0.5	...	7.7	79	...	0	...	...	...	...	...	...
			No. of Samples	9	9	9	3	...	9	8	8	...	6	6	...	6	...	...	...	...	...	...
		700	Median	3,500																		
			Average	...	8.6	1	0.019	...	12.0	10.0	0.98	15	7.8	81	0.4	1.5	...	3	...	...	170	63
			Maximum	24,000	16	15	0.18	0.25	24.5	14.3	4.5	29	8.0	84	0.8	6.7	...	10	...	...	180	84
			Minimum	230	5.0	0	0	0.15	0	8.0	0.16	3.5	7.6	78	0	0	...	1	...	...	140	46
			No. of Samples	28	26	26	16	4	22	27	27	15	6	6	3	11	...	5	...	2	3	3
		900	Median	3,300																		
			Average	...	9	2	0.05	...	8.5	11.5	1.4	...	7.7	81	...	1	...	...	...	...	...	...
			Maximum	9,300	15	10	0.08	...	16.0	13.6	4.3	...	8.0	85	...	2	...	...	...	...	...	...
			Minimum	2,000	5.8	0	0	...	0.5	9.4	0.57	...	7.6	79	...	0	...	...	...	...	...	...
			No. of Samples	9	9	9	3	...	9	8	8	...	6	6	...	5	...	...	...	...	...	...

		980	Median	7,500	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	18	7	0.01	0.19	12.5	10.1	1.01	15	7.8	81	0.4	2.0	...	1	...	...	160	61
			Maximum	46,000	25	50	0.18	0.30	24.5	14.2	4.5	31	8.0	84	0.8	6.7	...	2	...	...	180	84
			Minimum	700	5.9	0	0	0.1	0	7.2	0.1	3.2	7.7	78	0	0	...	1	...	...	150	32
			No. of Samples	28	26	27	17	4	22	26	26	15	6	6	3	11	...	4	...	...	3	3
Ecorse River at Jefferson Avenue	DtER-16.3	20	Median	24,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	30	10	...	7.0	...	6.9	2.6	...	6.0	48	...	9	...	...	...	...	...	...
			Maximum	46,000	33	20	...	13.7	...	7.3	3.0	...	7.2	80	...	16	...	...	...	...	...	...
			Minimum	2,300	27	0	...	1.4	...	6.5	2.3	...	5.8	16	...	2	...	...	...	...	...	...
			No. of Samples	2	2	2	...	2	...	2	2	...	2	2	...	2	...	...	...	...	...	...
		40	Median	56,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	26	10	...	7.0	...	5.3	4.1	...	6.5	50	...	9	...	...	...	...	...	...
			Maximum	110,000	34	20	...	13.0	...	7.3	6	...	7.3	81	...	16	...	...	...	...	...	...
			Minimum	2,300	18	0	...	1.4	...	3.4	2.2	...	5.8	16	...	2	...	...	...	...	...	...
			No. of Samples	2	2	2	...	2	...	2	2	...	2	2	...	2	...	...	...	...	...	...
		0			United States Shore																	
Southfield Road to Fighting Island, North Light (in vicinity of dredge dumping area)	Dt-16.8W	200	Median	9,300	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	36	10	0.28	...	...	7.0	2.60	21	...	83	...	...	...	...	...	...	...	...
			Maximum	9,300	36	10	0.28	...	...	7.0	2.60	21	...	83	...	...	...	...	...	...	...	...
			Minimum	9,300	36	10	0.28	...	...	7.0	2.60	21	...	83	...	...	...	...	...	...	...	...
			No. of Samples	1	1	1	1	...	...	1	1	1	...	1	...	...	...	...	...	...	...	...
		700	Median	75,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	33	4	0.20	...	23.5	6.6	1.90	14	...	...	...	...	...	...	...	...	...	...
			Maximum	75,000	33	4	0.20	...	23.5	6.6	1.90	14	...	...	...	...	...	...	...	...	...	...
			Minimum	75,000	33	4	0.20	...	23.5	6.6	1.90	14	...	...	...	...	...	...	...	...	...	...
			No. of Samples	1	1	1	1	...	1	1	1	1	...	...	...	...	...	...	...	...	...	...
		1,900	Median	46,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	18	4	0.06	...	22.5	7.7	1.30	8	...	...	1.4	...	...	...	...	...	...	...
			Maximum	46,000	18	4	0.06	...	22.5	7.7	1.30	8	...	...	1.4	...	...	...	...	...	...	...
			Minimum	46,000	18	4	0.06	...	22.5	7.7	1.30	8	...	...	1.4	...	...	...	...	...	...	...
			No. of Samples	1	1	1	1	...	1	1	1	1	...	...	1	...	...	...	...	...	...	...
		3,250	Median	2,400	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	15	7	0	...	22.0	8.6	0.28	11	...	...	...	...	...	...	...	...	...	...
			Maximum	2,400	15	7	0	...	22.0	8.6	0.58	11	...	...	...	...	...	...	...	...	...	...
			Minimum	2,400	15	7	0	...	22.0	8.6	0.58	11	...	...	...	...	...	...	...	...	...	...
			No. of Samples	1	1	1	1	...	1	1	1	1	...	...	...	...	...	...	...	...	...	...
		3,500	Median	4,300	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	6.3	0	0	...	22.0	8.7	0.74	11	...	...	2.4	...	...	...	...	...	140	58
			Maximum	4,300	6.3	0	0	...	22.0	8.7	0.74	11	...	...	2.4	...	...	...	...	...	140	58
			Minimum	4,300	6.3	0	0	...	22.0	8.7	0.74	11	...	...	2.4	...	...	...	...	...	140	58
			No. of Samples	1	1	1	1	...	1	1	1	1	...	...	1	...	...	...	...	...	1	1

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
Southfield Road to Fighting Island North Light (in vicinity of dredge dumping area (Continued)	Dt-16.8W	3,700	Median	2,400																		
			Average	...	6.0	0	0	...	22.0	8.8	0.37	8	...	...	3.4	...	...	...	...	...	130	62
			Maximum	2,400	6.0	0	0	...	22.0	8.8	0.37	8	...	...	3.4	...	...	...	...	...	130	62
			Minimum	2,400	6.0	0	0	...	22.0	8.8	0.37	8	...	...	3.4	...	...	...	...	...	130	62
			No. of Samples	1	1	1	1	...	1	1	1	1	...	...	1	...	...	...	...	...	1	1
		4,200	Median	2,300																		
			Average	...	7.7	5	0.004	...	...	8.6	0.79	14	...	82	...	...	...	...	...	...	...	...
			Maximum	2,300	7.7	5	0.004	...	...	8.6	0.79	14	...	82	...	...	...	...	...	...	...	...
			Minimum	2,300	7.7	5	0.004	...	...	8.6	0.79	14	...	82	...	...	...	...	...	...	...	...
			No. of Samples	1	1	1	1	...	...	1	1	1	...	1	...	...	...	...	...	...	...	...
		4,300	Median	2,400																		
			Average	...	7.4	5	0.006	...	...	8.5	0.62	15	...	82	3.4	...	...	...	...	...	200	130
			Maximum	2,400	7.4	5	0.006	...	...	8.5	0.62	15	...	82	3.4	...	...	...	...	...	200	130
			Minimum	2,400	7.4	5	0.006	...	...	8.5	0.62	15	...	82	3.4	...	...	...	...	...	200	130
			No. of Samples	1	1	1	1	...	...	1	1	1	...	1	1	...	...	...	...	...	1	1
		4,300			International Boundary																	
		4,400	Median	36																		
			Average	...	7.1	5	0	...	...	8.3	0.82	21	...	82	...	...	...	...	...	...	...	...
			Maximum	36	7.1	5	0	...	...	8.3	0.82	21	...	82	...	...	...	...	...	...	...	...
			Minimum	36	7.1	5	0	...	...	8.3	0.82	21	...	82	...	...	...	...	...	...	...	...
			No. of Samples	1	1	1	1	...	...	1	1	1	...	1	...	...	...	...	...	...	...	...
		4,900			West Shore Fighting Island								Cyanide as CN ppm									
		0			United States Shore																	
Wyandotte Chemicals Coke Plant Intake across to Grassy Island Light	Dt-15.6W	5	Median																			
			Average	...	81	23	0.18	...	5.5	11.0	2.6	16	1	...	...	...	...	...	...	...	...	...
			Maximum	...	173	25	0.28	...	6.0	11.4	2.9	25	1	...	...	...	...	...	...	...	...	...
			Minimum	...	36	15	0.04	...	5.0	10.4	2.1	6	1	...	...	...	...	...	...	...	...	...
			No. of Samples	...	4	4	4	...	3	4	4	4	1	...	...	...	...	...	...	...	...	...
		20	Median	24,000																		
			Average	...	35	23	0.20	...	8.5	10.5	2.4	17	0.5	...	...	...	...	...	...	...	...	...
			Maximum	43,000	44	30	0.36	...	17.5	11.6	2.9	26	0.5	...	...	...	...	...	...	...	...	...
			Minimum	23,000	27	15	0.04	...	5.0	8.3	2.1	9	0.5	...	...	...	...	...	...	...	...	...
			No. of Samples	5	5	5	5	...	4	5	5	5	1	...	...	...	...	...	...	...	...	...

		100	Median	21,000																		
			Average		32	21	0.20		8.0	10.7	2.3	18	0.5									
			Maximum	93,000	37	32	0.32		17.5	11.6	2.9	33	0.5									
			Minimum	2,300	25	10	0.04		4.0	8.8	1.8	11	0.5									
			No. of Samples	5	5	5	5		4	5	5	5	1									
		200	Median	23,000																		
			Average		29	21	0.11		8.0	10.8	2.1	16										
			Maximum	43,000	35	32	0.24		17.0	11.9	3.9	26										
			Minimum	9,300	21	8	0.01		4.0	9.3	1.5	9										
			No. of Samples	5	5	5	5		4	5	5	5										
		400	Median	15,000																		
			Average		23	11	0.04		7.5	11.1	1.7	16										
			Maximum	46,000	28	20	0.06		16.5	12.3	2.3	27										
			Minimum	2,300	17	0	0		4.0	9.6	0.9	7										
			No. of Samples	5	5	5	5		4	5	5	5										
		700	Median	4,300																		
			Average		15	5	0.003		8.0	11.4	1.02	14										
			Maximum	24,000	21	13	0.016		17.0	12.1	1.60	26										
			Minimum	930	8.5	0	0		4.0	9.8	0.60	6										
			No. of Samples	5	5	5	5		4	5	5	5										
		1,000	Median	9,300																		
			Average		12	5	0		8.0	11.7	0.95	13										
			Maximum	11,000	17	13	0		17.0	12.4	1.30	20										
			Minimum	430	8.4	0	0		4.0	10.5	0.56	8										
			No. of Samples	5	5	5	5		4	5	5	5										
		1,500			West Shore Grassy Island																	
		3,000			International Boundary																	
		4,400			West Shore Fighting Island																	
		0			United States Shore																	
Wyandotte City Power Plant and Water Works Dock over Intake and through Cut to Fighting Island	Dt-14.6W	20	Median	43,000																		
			Average		52	18	0.35		11.0	10.0	2.3	18		88								
			Maximum	240,000	69	30	0.68		18.0	11.5	3.1	29		88								
			Minimum	9,300	36	10	0.06		5.0	8.4	1.8	11		88								
			No. of Samples	9	9	9	9		8	9	9	9		1								
		100	Median	43,000																		
			Average		37	17	0.18		12.0	10.0	2.1	16										
			Maximum	460,000	58	30	0.44		23.5	11.6	2.6	33										
			Minimum	23,000	28	5	0.01		5.0	7.0	1.6	7										
			No. of Samples	10	10	10	10		9	10	10	10										

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
Wyandotte City Power Plant and Water Works Dock over Intake and through Cut to Fighting Island (Continued)	Dt-14.6W	200	Median	70,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	35	8	0.14	...	16.0	9.1	1.8	11	...	...	...	...	...	...	...	...	...	...
			Maximum	93,000	43	9	0.27	...	17.0	9.4	1.8	13	...	...	...	...	...	...	...	...	...	...
			Minimum	43,000	28	7	0.004	...	15.0	8.8	1.7	8	...	...	...	...	...	...	...	...	...	...
			No. of Samples	4	4	4	4	...	4	4	4	4	...	...	...	...	...	...	...	...	...	...
		300	Median	43,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	28	13	0.10	...	11.0	10.4	1.9	15	...	...	...	...	...	...	...	...	...	...
			Maximum	93,000	40	22	0.28	...	17.0	11.8	2.6	27	...	...	...	...	...	...	...	...	...	...
			Minimum	23,000	23	5	0	...	4.0	8.9	1.3	8	...	...	...	...	...	...	...	...	...	...
			No. of Samples	9	9	9	9	...	7	9	9	9	...	...	...	...	...	...	...	...	...	...
		400	Median	33,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	26	7	0.06	...	16.0	9.3	1.7	13	...	...	...	...	...	...	...	...	...	...
			Maximum	93,000	30	9	0.17	...	17.0	9.5	2.1	16	...	...	...	...	...	...	...	...	...	...
			Minimum	24,000	23	5	0	...	15.5	9.2	1.4	8	...	...	...	...	...	...	...	...	...	...
			No. of Samples	4	4	4	4	...	4	4	4	4	...	...	...	...	...	...	...	...	...	...
		600	Median	19,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	24	10	0.04	...	10.5	10.6	1.7	15	...	...	...	...	...	...	...	...	...	...
			Maximum	93,000	28	22	0.24	...	17.5	11.8	3.2	25	...	...	...	...	...	...	...	...	...	...
			Minimum	3,900	18	4	0	...	4.0	9.2	1.0	9	...	...	...	...	...	...	...	...	...	...
			No. of Samples	8	9	9	9	...	8	9	9	9	...	...	...	...	...	...	...	...	...	...
		800	Median	24,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	21	7	0.01	...	10.0	10.8	1.3	13	...	...	...	...	...	...	...	...	...	...
			Maximum	75,000	26	15	0.04	...	17.5	11.9	1.8	23	...	...	...	...	...	...	...	...	...	...
			Minimum	910	10	2	0	...	4.0	9.2	0.8	8	...	...	...	...	...	...	...	...	...	...
			No. of Samples	9	9	9	9	...	8	9	9	9	...	...	...	...	...	...	...	...	...	...
		900	Median	4,300	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	15	5	0.004	...	11.5	10.5	1.6	12	...	...	...	...	...	...	...	...	...	...
			Maximum	93,000	19	15	0.04	...	23.0	12.0	7.20	21	...	...	...	...	...	...	...	...	...	...
			Minimum	930	8	0	0	...	5.0	8.4	0.43	7	...	...	...	...	...	...	...	...	...	...
			No. of Samples	11	10	11	11	...	9	11	11	11	...	...	...	...	...	...	...	...	...	...
		1,000	Median	2,400	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	9.8	1	0	...	10.0	11.2	0.77	16	...	...	...	...	...	...	...	...	...	...
			Maximum	15,000	14	5	0	...	16.0	12.2	1.30	37	...	...	...	...	...	...	...	...	...	...
			Minimum	910	6.7	0	0	...	4.0	9.9	0.28	7	...	...	...	...	...	...	...	...	...	...

			No. of Samples	9	9	9	9	...	8	9	9	9	...	...	...	...	...	...	...	...	...	...
		1,100	Median	3,100	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	8.6	1	0.002	...	14.0	10.5	0.68	10	...	82	1.5	...	...	...	...	...	180	120
			Maximum	43,000	13.0	15	0.02	...	23.0	12.2	1.60	32	...	82	1.5	...	...	...	...	...	180	120
			Minimum	230	6.0	0	0	...	5.0	8.6	0.26	7	...	82	1.5	...	...	...	...	...	180	120
			No. of Samples	22	22	22	22	...	20	22	22	22	...	1	1	...	...	...	...	...	1	1
		2,000	Median	2,400	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	8.0	2	0	...	15.0	10.2	0.51	9	...	...	...	...	...	...	...	...	...	...
			Maximum	4,600	10	5	0	...	16.0	10.3	0.62	11	...	...	...	...	...	...	...	...	...	...
			Minimum	240	6.6	0	0	...	14.5	10.1	0.44	6	...	...	...	...	...	...	...	...	...	...
			No. of Samples	3	3	3	3	...	3	3	3	3	...	...	...	...	...	...	...	...	...	...
		2,300	Median	1,300	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	6.5	11	0	...	22.5	8.6	0.56	11	...	82	...	...	...	...	...	...	...	...
			Maximum	2,400	6.9	15	0	...	22.5	8.7	0.65	11	...	82	...	...	...	...	...	...	...	...
			Minimum	230	6.1	6	0	...	22.5	8.5	0.46	10	...	82	...	...	...	...	...	...	...	...
			No. of Samples	2	2	2	2	...	2	2	2	2	...	1	...	...	...	...	...	...	...	...
		3,000	Median	650	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	9.5	12	0	...	16.5	9.7	0.43	8	...	...	2.9	...	...	...	...	...	140	78
			Maximum	930	12	40	0	...	22.0	10.2	0.66	10	...	...	2.9	...	...	...	...	...	140	78
			Minimum	43	6.3	0	0	...	14.5	8.8	0.26	7	...	...	2.9	...	...	...	...	...	140	78
			No. of Samples	4	4	4	4	...	4	4	4	4	...	...	1	...	...	...	...	...	1	1
		3,700			International Boundary																	
		4,000	Median	930	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	5.5	2	0	...	15.0	10.1	0.47	8	...	...	...	...	...	...	...	...	...	...
			Maximum	2,400	6.7	5	0	...	16.0	10.2	0.62	10	...	...	...	...	...	...	...	...	...	...
			Minimum	910	4.8	0	0	...	14.5	9.9	0.28	7	...	...	...	...	...	...	...	...	...	...
			No. of Samples	3	3	3	3	...	3	3	3	3	...	...	...	...	...	...	...	...	...	...
		6,000			West Shore, Fighting Island																	
		0			United States Shore																	
Trenton Channel Toll Bridge from United States Mainland Shore to West Shore Grosse Isle	Dt-12.0W	122	Median	22,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	50	17	0.04	0.41	7.0	10.7	2.3	15	7.8	86	0.3	3.7	...	3	...	...	240	140
			Maximum	240,000	85	56	2.40	0.90	24.5	14.6	4.7	29	8.2	94	0.8	16	...	6	...	...	270	150
			Minimum	<300	26	0	0.00	0.20	0	4.9	0.0	4	7.4	82	0	1	...	1	...	...	210	110
			No. of Samples	44	37	38	23	14	39	40	39	23	23	22	3	22	...	4	...	2	3	3
		322	Median	20,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	34	24	...	1.28	9.0	9.6	2.1	...	7.8	84	...	1	...	...	...	...	...	...
			Maximum	110,000	42	160	...	4.47	18.5	14.7	3.6	...	7.9	92	...	2	...	...	...	...	...	...
			Minimum	3,900	30	0	...	0.41	0	5.0	0	...	7.4	79	...	1	...	...	...	...	...	...
			No. of Samples	12	11	10	...	5	12	10	9	...	11	11	...	10	...	...	...	...	...	...

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
Trenton Channel Toll Bridge from United States Mainland Shore to West Shore Grosse Ile (Continued)	Dt-12.0W	490	Median	17,000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	28	14	0.16	0.80	6.5	12.4	2.1	14	7.7	85	0.4	3.2	....	1	....	....	....	....
			Maximum	460,000	44	50	0.85	9.42	24.0	14.8	4.8	32	7.9	93	0.7	16	....	2	....	....	....	....
			Minimum	2,300	18	0	0.00	0.20	0	5.2	0.0	4	7.2	74	0	0	....	1	....	....	....	....
			No. of Samples	43	37	38	24	13	38	39	38	24	22	21	3	21	....	4	....	2	....	....
		670	Median	9,300	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	20	12	....	0.41	8.0	10.2	1.6	....	7.8	84	....	1	....	....	....	....	....	....
			Maximum	54,000	30	70	....	0.76	18.5	15.0	3.3	....	7.9	90	....	4	....	....	....	....	....	....
			Minimum	4,300	17	0	....	0.30	0	5.4	0.0	....	7.5	81	....	0	....	....	....	....	....	....
			No. of Samples	12	11	10	....	6	12	11	10	....	11	11	....	10	....	....	....	....	....	....
		880	Median	9,300	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	21	16	0.12	0.38	6.6	10.6	1.8	12	7.7	83	0.3	1	....	1	....	....	....	....
			Maximum	1,100,000	32	130	1.36	1.10	23.5	14.8	3.5	23	7.9	92	0.7	8	....	2	....	....	....	....
			Minimum	2,300	12	0	0	0.20	0	5.4	0.0	3	7.3	72	0.0	0	....	1	....	....	....	....
			No. of Samples	43	37	38	22	12	38	38	36	22	22	21	3	21	....	4	....	2	....	....
		1,100			West	Shore	Grosse Ile															
Menguagan Creek at Biddle Street	DtMe-12.2		Median	220	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	300	3,490	7.8	....	8.6	5.1	98	27	9.4	150	....	1,920	....	....	....	....	....	....
			Maximum	2,300	400	17,500	20.0	....	15.0	10.1	>320	54	9.6	220	....	8,200	....	....	....	....	....	....
			Minimum	14	130	45	0.5	....	3.0	0.1	15.9	14	8.9	120	....	512	....	....	....	....	....	....
			No. of Samples	10	10	10	10	....	10	10	10	10	10	10	....	10	....	....	....	....	....	....
		0			East	Shore	Grosse Ile															
Grosse Ile to Canadian Shore above Stony Island	Dt-9.3E	100	Median	4,900	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	24	14	0.013	0.25	11.5	9.6	1.6	12	8.0	80	0.2	2.7	....	1.7	....	....	160	73
			Maximum	92,000	28	150	0.04	0.4	24.5	11.9	3.2	46	8.0	80	0.5	6.7	....	5	....	....	180	94
			Minimum	2,300	13	0	0	0.1	2.0	7.4	0.40	1.6	8.0	80	0	0	....	1	....	....	140	58
			No. of Samples	14	13	14	7	6	8	14	14	10	1	1	3	7	....	6	....	4	5	5
		200	Median	9,200	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	20	3	0.003	0.13	11.5	9.5	1.9	11	7.9	80	0.4	2.4	....	2	....	....	160	78
			Maximum	110,000	25	15	0.02	0.20	24.5	12.0	9.4	32	7.9	80	0.9	6.7	....	5	....	....	190	96
			Minimum	2,100	13	0	0	0.05	2.0	7.8	0.65	0.7	7.9	80	0	0	....	1	....	....	130	70
			No. of Samples	14	13	14	7	6	8	14	14	10	1	1	3	1	....	6	1	....	5	5
		500	Median	2,600	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
			Average	....	18	2	0.01	0.20	13.0	9.6	1.2	11	8.0	78	....	2	....	1	....	....	160	51
			Maximum	35,000	36	9	0.06	0.30	24.5	12.0	2.3	21	8.0	78	....	3	....	1	....	....	170	62

	Minimum	490	13	0	0	0.10	2.0	6.3	0.48	0.6	8.0	78	....	0	....	1	....	....	140	40
	No. of Samples	11	11	12	8	6	9	12	11	8	1	1	....	4	....	3	....	3	2	2
800	Median	2,900																		
	Average	....	17	1	0.01	....	11.0	9.9	1.3	....	7.7	71	....	0	0	....	....	....	....	....
	Maximum	4,300	18	2	0.02	....	14.0	11.8	2.2	....	7.7	71	....	0	....	....	....	....	....	....
	Minimum	1,500	16	0	0	....	9.0	6.1	0.3	....	7.7	71	....	0	....	....	....	....	....	....
	No. of Samples	2	3	3	2	....	3	3	3	....	1	1	....	1	....	....	....	....	....	....
1,200	Median	3,900																		
	Average	....	18	2	0.004	0.11	11.5	9.5	1.5	8	8.0	80	1.4	2	....	3.5	....	....	160	76
	Maximum	54,000	36	8	0.02	0.20	24.5	12.0	5.0	18	8.0	80	5	4	....	5	....	....	190	94
	Minimum	330	12	0	0	0	2.0	6.1	0.4	0.8	8.0	80	0	0	....	1	....	....	130	60
	No. of Samples	14	13	14	5	9	8	14	14	10	1	1	6	4	....	6	....	3	5	5
1,500	Median	1,500																		
	Average	....	13	6	0.02	....	10.5	9.8	1.1	....	8.0	84	....	0	....	....	....	....	....	....
	Maximum	4,300	16	16	0.04	....	9.0	11.8	1.5	....	8.0	84	....	0	....	....	....	....	....	....
	Minimum	490	10	0	0	....	8.5	5.8	0.4	....	8.0	84	....	0	....	....	....	....	....	....
	No. of Samples	3	3	3	2	....	3	3	3	....	1	1	....	1	....	....	....	....	....	....
2,000	Median	5,800																		
	Average	....	15	2	0	0.14	11.5	9.2	1.2	7	7.8	81	0.07	1.6	....	2	....	....	160	78
	Maximum	>24,000	23	6	0	0.20	24.5	12.1	4.8	16	7.8	81	0.2	4	....	5	....	....	180	110
	Minimum	790	11	0	0	0.1	2.0	5.6	0.3	1.3	7.8	81	0	0	....	1	....	....	140	58
	No. of Samples	14	13	14	7	7	8	14	14	10	1	1	3	7	....	6	....	3	5	5
2,500	Median	9,300																		
	Average	....	11	1	0.01	....	10.5	9.7	0.75	....	7.9	80	....	0	....	....	....	....	....	....
	Maximum	13,000	15	2	0.02	....	13.5	11.8	1.3	....	7.9	80	....	0	....	....	....	....	....	....
	Minimum	2,400	6.4	0	0	....	8.5	5.5	0.3	....	7.9	80	....	0	....	....	....	....	....	....
	No. of Samples	3	3	3	2	....	3	3	3	....	1	1	....	1	....	....	....	....	....	....
3,000	Median	3,000																		
	Average	....	12	2	0	0.12	11.5	9.3	1.2	9	7.9	82	0.3	1.7	....	1.1	....	....	170	81
	Maximum	13,000	22	6	0	0.20	25.0	12.1	7.8	23	7.9	82	0.4	4	....	2	....	....	180	96
	Minimum	430	3.2	0	0	0.1	2.0	5.5	0.2	1.6	7.9	82	0	0	....	1	....	....	150	52
	No. of Samples	14	12	14	7	7	8	14	14	9	1	1	3	7	....	6	....	3	4	4
3,300	Median	4,600																		
	Average	....	17	1	0.001	0.17	11.5	9.7	0.66	8	7.9	80	....	3	....	1	....	....	150	76
	Maximum	17,000	23	4	0.006	0.2	25.0	12.1	1.0	20	7.9	80	....	5	....	1	....	....	170	82
	Minimum	930	3.7	0	0	0.1	2.0	5.5	0.2	0.5	7.9	80	....	0	....	1	....	....	130	70
	No. of Samples	11	10	11	7	3	8	11	10	7	1	1	....	4	....	3	....	3	2	2
3,600	Median	2,400																		
	Average	....	10	1	0	0.17	11.5	9.7	0.65	11	7.9	81	....	1.8	....	1	....	....	150	83
	Maximum	>24,000	23	5	0	0.2	25.0	12.1	1.6	19	7.9	81	....	5	....	1	....	....	160	92
	Minimum	91	4.5	0	0	0.1	2.0	5.6	0.30	0.6	7.9	81	....	0	....	1	....	....	130	74
	No. of Samples	11	10	11	7	3	8	11	11	6	1	1	....	4	....	3	....	3	2	2

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

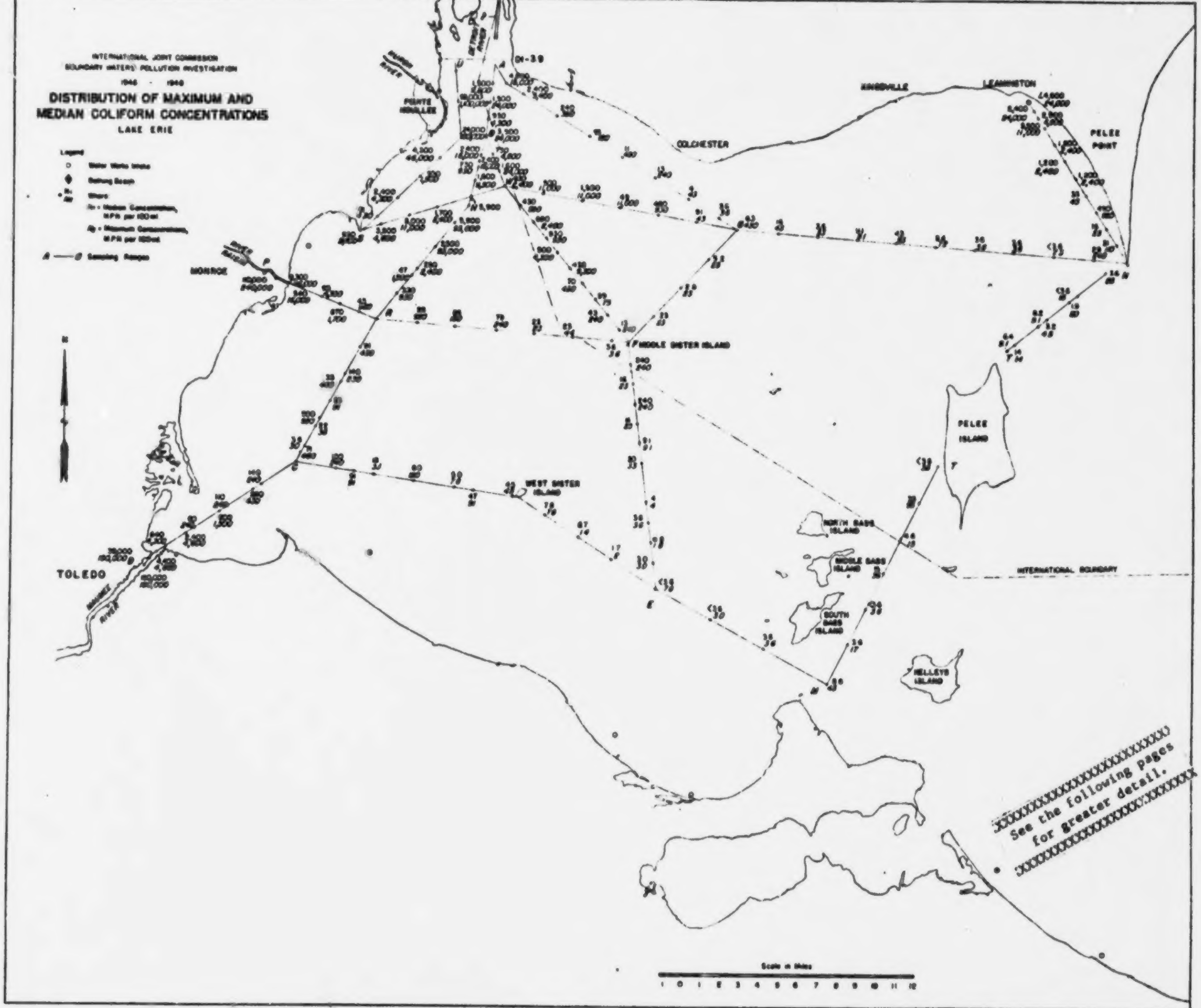
Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
Grosse Ile to Canadian Shore above Stony Island (Continued)	Dt-9.3E	3,700			International Boundary																	
		4,000	Median	1,300																		
			Average	...	8.6	2	0.05	0.13	11.0	9.2	0.35	8	7.8	81	1.2	1.7	...	1.7	...	...	150	74
			Maximum	16,000	12.0	20	0.32	0.2	25.0	12.3	1.0	21	7.8	81	1.7	3	...	5	...	...	170	92
			Minimum	23	1.9	0	0	0.1	2.0	5.7	0	1.1	7.8	81	0.5	0	...	1	...	...	120	50
			No. of Samples	14	13	14	7	7	8	14	13	10	1	1	3	7	...	6	...	3	5	5
		4,500	Median	1,100																		
			Average	...	10	4	0	0.14	11.0	9.5	0.83	10	7.9	82	1.1	3.2	...	2.2	...	...	140	65
			Maximum	24,000	19	6	0	0.2	25.0	12.2	3.6	26	7.9	82	2.7	6.7	...	5	...	...	170	70
			Minimum	91	1.0	0	0	0.1	2.0	5.6	0.20	1.2	7.9	82	0	0	...	1	...	...	120	58
			No. of Samples	14	13	14	7	7	8	14	14	10	1	1	3	7	...	6	...	4	5	5
		4,800	Median	2,400																		
			Average	...	16	3	...	0.12	...	8.3	0.87	3.6	...	...	0.6	1.7	...	2.3	...	...	160	73
			Maximum	>2,400	18	8	...	0.15	...	8.8	1.8	5.6	...	...	1.3	3	...	5	...	...	170	82
			Minimum	1,700	13	4	...	0.1	...	7.6	0.2	2.4	...	...	0.2	1	...	1	...	...	140	64
			No. of Samples	3	3	4	...	3	...	3	3	3	...	...	3	3	...	3	...	1	3	3
		5,000	Median	2,400																		
			Average	...	12	1	0.001	0.13	11.0	9.7	0.59	14	7.8	81	...	4	...	2.9	...	...	160	90
			Maximum	54,000	18	5	0.004	0.2	25.0	12.4	1.4	25	7.8	81	...	10	...	6.7	...	...	160	110
			Minimum	43	7.5	0	0	0.1	2.0	5.6	0.2	1.2	7.8	81	...	1	...	1	...	...	160	70
			No. of Samples	11	10	11	7	6	8	11	11	7	1	1	...	3	...	3	...	3	2	2
		5,300	Median	6,200																		
			Average	...	13	6	0.08	0.17	11.0	9.4	0.73	10	7.9	82	0.4	1.6	...	1.1	...	...	160	78
			Maximum	>24,000	19	8	0.50	0.2	25.0	12.4	1.8	31	7.9	82	0.4	4	...	2	...	...	180	120
			Minimum	2,300	6.5	0	0	0.1	2.0	5.7	0.2	0.7	7.9	82	0.3	1	...	1	...	...	140	58
			No. of Samples	14	13	14	7	7	8	14	14	10	1	1	2	7	...	6	...	3	5	5
		5,600	Median	8,600																		
			Average	...	12	2	0.003	0.16	11.5	9.3	0.77	12	8.0	82	0.5	8.8	...	7.1	...	...	160	180
			Maximum	>24,000	15	8	0.02	0.25	25.0	12.5	1.4	31	8.0	82	1.0	28.5	...	33.3	...	...	180	110
			Minimum	2,300	6.5	0	0	0.1	2.0	5.6	0.2	1.2	8.0	82	0	1	...	1	...	...	140	62
			No. of Samples	14	13	14	7	7	8	14	13	10	1	1	2	7	...	6	...	3	5	5
		5,800	Median	4,300																		
			Average	...	13	1	0.06	0.23	11.5	8.9	1.06	14	8.0	83	0.4	2.4	...	2.0	...	...	170	86

			Maximum	>24,000	16	6	0.04	0.6	25.0	12.4	2.6	39	8.0	83	0.5	3	...	6.7	...	...	200	110
			Minimum	2,300	8.0	0	0	0.1	2.0	5.60	0.5	0.6	8.0	83	0.2	2	...	1	...	...	150	72
			No. of Samples	14	13	14	8	7	8	13	13	10	1	1	2	7	...	6	...	4	5	5
		6,000			Canadian Shore																	
		0			United States Shore																	
Maple Beach above Huron River outlet to Sunset Beach, Bar Point (near mouth of Detroit River)	Dt- 3.9	500	Median	5,400	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	54	11	0.20	0.35	12.0	9.3	2.23	12	...	...	...	5	...	2.5	...	...	230	130
			Maximum	9,300	68	30	0.32	0.35	28.5	12.9	6.0	26	...	...	...	6.7	...	4	...	...	320	180
			Minimum	430	18	0	0.004	0.35	0	7.0	0	1.1	...	...	...	3	...	1	...	...	140	70
			No. of Samples	9	9	9	7	2	6	9	9	7	...	...	...	2	...	2	...	2	2	2
		1,500	Median	6,900	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	55	13	0.23	0.2	12.0	8.4	1.97	13	...	...	...	5.3	...	3.5	...	...	250	130
			Maximum	110,000	73	30	0.38	0.2	28.0	12.9	3.5	25	...	...	...	6.7	...	4	...	...	330	170
			Minimum	2,300	16	0	0.002	0.2	0	5.4	0.4	0.7	...	...	...	4	...	3	...	...	160	90
			No. of Samples	8	9	9	7	2	6	9	9	7	...	...	...	2	...	2	...	2	2	2
		2,500	Median	24,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	54	9	0.28	0.23	12.0	8.4	2.1	13	...	...	...	4	...	2.5	...	...	230	90
			Maximum	>240,000	77	20	0.42	0.25	28.0	13.0	3.4	23	...	...	...	4	...	4	...	...	290	120
			Minimum	4,600	18	0	0.12	0.2	0	5.2	1.2	1.5	...	...	...	4	...	1	...	...	160	64
			No. of Samples	8	9	9	7	2	6	9	9	7	...	...	...	2	...	2	...	2	2	2
		3,500	Median	15,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	50	10	0.21	0.23	11.5	8.5	2.0	12	...	...	...	3	...	1	...	...	220	120
			Maximum	>240,000	72	17	0.40	0.30	27.0	13.0	3.1	21	...	...	...	4	...	1	...	...	280	160
			Minimum	9,300	14	0	0	0.15	0	5.4	0.99	1.2	...	...	...	2	...	1	...	...	150	78
			No. of Samples	9	9	9	7	2	6	9	9	7	...	...	...	2	...	2	...	2	2	2
		4,500	Median	43,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	40	8	18	0.2	11	8.7	2.3	11	...	...	...	9.3	...	1	...	...	200	100
			Maximum	110,000	67	15	0.30	0.2	26	13.0	3.6	21	...	...	...	13	...	1	...	...	260	140
			Minimum	15,000	14	0	0	0.2	0	5.4	1.1	1.0	...	...	...	6.7	...	1	...	...	130	60
			No. of Samples	9	9	9	7	2	6	9	9	7	...	...	...	2	...	2	...	2	2	2
		5,500	Median	24,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	34	7	0.14	0.23	12	8.1	1.8	11	...	...	...	6	...	1	...	...	190	100
			Maximum	>240,000	65	12	0.34	0.30	26	13.2	3.5	19	...	...	...	8	...	1	...	...	230	130
			Minimum	4,300	14	0	0	0.15	0	5.4	0.98	1.3	...	...	...	4	...	1	...	...	140	64
			No. of Samples	7	7	7	5	2	4	7	7	7	...	...	...	2	...	2	...	2	2	2
		6,500	Median	43,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
			Average	...	36	6	0.15	0.23	11	8.7	2.3	13	...	...	...	5.4	...	1	...	...	200	110
			Maximum	>240,000	62	15	0.34	0.30	26	12.2	3.6	24	...	...	...	6.7	...	1	...	...	210	120
			Minimum	7,500	19	0	0	0.15	0	5.1	1.1	1.8	...	...	...	4	...	1	...	...	180	96
			No. of Samples	9	9	9	7	2	6	9	9	7	...	...	...	2	...	2	...	2	2	2

TABLE 21—SUMMARY OF AVERAGE ANALYTICAL RESULTS—DETROIT RIVER—Continued

Sampling Point	Mileage Index No.	Distance from West Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alk. ppm	Oils ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
																Raw		Chlorinated				
																No.	Nature	No.	Nature		Total	Volatile
Maple Beach above Huron River outlet to Sunset Beach, Bar Point (near Mouth of Detroit River) (Continued)	Dt- 3.9	7,500	Median	43,000																		
			Average		32	6	0.10	0.18	11	8.8	1.7	11				5.9		1.5			210	120
			Maximum	>240,000	54	12	0.36	0.2	26.0	13.5	3.2	18				6.7		2			210	130
			Minimum	4,300	18	0	0	0.15	0	5.2	0.55	1.3				5		1			200	100
			No. of Samples	9	9	9	7	2	6	9	9	7				2		2		2	2	2
		8,500	Median	22,000																		
			Average		28	4	0.07	0.18	11	9.1	1.7	11				4.5		1			190	120
			Maximum	46,000	53	12	0.30	0.20	26	13.3	2.4	20				5		1			200	120
			Minimum	4,300	17	0	0	0.15	0	5.4	0.86	1.2				4		1			180	120
			No. of Samples	9	9	9	7	2	6	9	9	7				2		2		2	2	2
		9,500	Median	7,500																		
			Average		22	3	0.05	0.2	11	9.4	1.2	10				6		2.5			150	89
			Maximum	46,000	34	10	0.20	0.2	26	13.6	2.2	20				8		4			170	92
			Minimum	750	14	0	0	0.2	0	6.1	0.4	1.1				4		1			120	86
			No. of Samples	9	9	9	7	2	6	9	9	7				2		2		2	2	2
		10,500	Median	3,500																		
			Average		19	3	0.03	0.1	11	9.7	0.79	8				5		2			160	110
			Maximum	46,000	29	10	0.14	0.1	25.5	13.7	1.7	16				5		2			180	110
			Minimum	930	14	0	0	0.1	0	6.3	0.2	1.0				5		1			130	100
			No. of Samples	9	9	9	7	2	6	9	9	7				2		2		2	2	2
		11,200			International Boundary																	
		11,500	Median	930																		
			Average		14	4	0	0.13	11	9.9	0.63	8				2.5		1			160	90
			Maximum	9,300	31	12	0	0.15	25.5	13.7	0.80	19				1		1			200	98
			Minimum	230	6	0	0	0.10	0	7.0	0.37	17				4		1			120	82
			No. of Samples	9	9	9	7	2	6	9	8	7				2		2		2	2	2
		12,500	Median	430																		
			Average		12	2	0	0.1	11	10.2	0.82	10				3.5		1			150	90
			Maximum	9,300	15	7	0	0.1	25.5	13.7	2.3	19				5		1			170	90
			Minimum	210	6.3	0	0	0.1	0	7.6	0.4	1.7				2		1			120	90
			No. of Samples	9	9	9	7	2	6	9	9	7				2		2		2	2	2
		13,500	Median	930																		
			Average		11	3	0	0.1	11	10.2	0.81	9				2.5		1			130	91
			Maximum	9,300	26	12	0	0.1	25.5	13.7	2.0	17				3		1			130	110
			Minimum	93	5.6	0	0	0.1	0	7.9	0.34	1.0				2		1			120	72

			No. of Samples	9	9	9	7	2	6	9	9	7	....	....	....	2	....	2	....	2	2	2
		14,500	Median	230																		
			Average	....	10	3	0	0.13	11	10.3	7.0	10	....	....	....	2	....	1	....	....	130	74
			Maximum	24,000	18	10	0	0.15	25.0	13.8	1.4	16	....	....	....	3	....	1	....	....	140	80
			Minimum	43	5.3	0	0	0.10	0	8.2	0.22	1.1	....	....	....	1	....	1	....	....	120	68
			No. of Samples	9	9	9	7	2	6	9	9	7	....	....	....	2	....	2	....	2	2	2
		15,000	Median	750																		
			Average	....	11	4	0	0.1	10.5	10.2	0.63	11	....	....	....	2.5	....	1	....	....	130	75
			Maximum	4,300	16	12	0	0.1	25.5	13.6	1.3	25	....	....	....	3	....	1	....	....	140	78
			Minimum	91	7.7	0	0	0.1	0	8.0	0.36	1	....	....	....	2	....	1	....	....	120	72
			No. of Samples	9	9	9	7	2	6	9	9	7	....	....	....	2	....	2	....	2	2	2
		16,200	Median	2,400																		
			Average	....	12	2	0	0.1	10.5	10.2	0.74	12	....	....	13.8	2.5	....	1	....	....	150	88
			Maximum	9,300	20	7	0	0.1	24.5	13.7	1.2	32	....	....	14.5	3	....	1	....	....	150	94
			Minimum	230	7.5	0	0	0.1	0	8.1	0.26	1.5	....	....	12	2	....	1	....	....	140	82
			No. of Samples	9	7	9	7	2	6	9	9	7	....	....	2	2	....	2	....	2	2	2
		16,500	Median	4,600																		
			Average	....	14	2	0	0.1	10.5	10.2	0.72	13	....	....	....	4	....	4	....	....	210	74
			Maximum	21,000	17	12	0	0.1	24.0	13.9	1.5	32	....	....	....	4	....	1	....	....	310	78
			Minimum	230	11	0	0	0.1	0	8.1	0	2.1	....	....	....	4	....	1	....	....	110	70
			No. of Samples	9	9	9	7	2	6	9	9	7	....	....	....	2	....	2	....	2	2	2
		17,500	Median	4,600																		
			Average	....	20	3	0.002	0.15	10.5	10.0	0.82	14	....	....	....	3.5	....	1	....	....	150	54
			Maximum	16,000	29	12	0.01	0.15	24.5	13.8	1.5	33	....	....	....	4	....	1	....	....	150	88
			Minimum	930	11	0	0	0.15	0	7.9	0.4	1.6	....	....	....	3	....	1	....	....	150	20
			No. of Samples	9	9	9	7	2	6	9	9	7	....	....	....	2	....	2	....	2	2	2
		18,500	Median	4,600																		
			Average	....	21	4	0.001	0.13	10.5	10.1	0.96	19	....	....	....	3.5	....	1	....	....	150	72
			Maximum	12,000	32	16	0.01	0.15	25.5	14.0	1.5	42	....	....	....	5	....	1	....	....	150	72
			Minimum	750	11	0	0	0.10	0	7.8	0.6	1.6	....	....	....	2	....	1	....	....	150	72
			No. of Samples	9	9	9	9	2	6	9	9	7	....	....	....	2	....	2	....	2	1	1
		19,000	Median	7,500																		
			Average	....	24	3	0.001	0.15	11.0	10.0	0.89	16	....	....	....	3.5	....	1.5	....	....	160	83
			Maximum	>24,000	32	8	0.01	0.15	25.5	14.0	1.4	36	....	....	....	5	....	2	....	....	160	92
			Minimum	2,100	12	0	0	0.15	0	7.6	0.2	1.3	....	....	....	2	....	1	....	....	160	74
			No. of Samples	9	9	9	7	2	6	9	9	7	....	....	....	2	....	2	....	2	2	2
		19,300	Median	4,300																		
			Average	....	25	5	0.001	0.15	11	10.0	0.83	20	....	....	....	4.9	....	1.5	....	....	220	100
			Maximum	11,000	34	25	0.01	0.10	25.5	13.5	1.7	33	....	....	....	6.7	....	2	....	....	260	130
			Minimum	2,300	12	0	0	0.20	0	7.4	0.2	1.7	....	....	....	3	....	1	....	....	170	78
			No. of Samples	6	9	9	9	2	6	9	9	7	....	....	....	2	....	2	....	2	2	2
		20,000			Canadian Shore																	


INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948
DISTRIBUTION OF MAXIMUM AND MEDIAN COLIFORM CONCENTRATIONS
LAKE ERIE
Legend
Water Works Intake
Bathing Beach
Mn = Median Concentration, MPN per 100ml
Mx = Maximum Concentration, MPN per 100ml
A — B Sampling Ranges
MONROE
TOLEDO
POINTE MOUILLEE
DI-3B
KINGSVILLE
LEAMINGTON
COLCHESTER
PELEE POINT
MIDDLE SISTER ISLAND
WEST SISTER ISLAND
PELEE ISLAND
NORTH BASS ISLAND
MIDDLE BASS ISLAND
SOUTH BASS ISLAND
KELLEYS ISLAND
INTERNATIONAL BOUNDARY
Scale in Miles
0 1 2 3 4 5 6 7 8 9 10 11 12

XXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXX

Figure 11

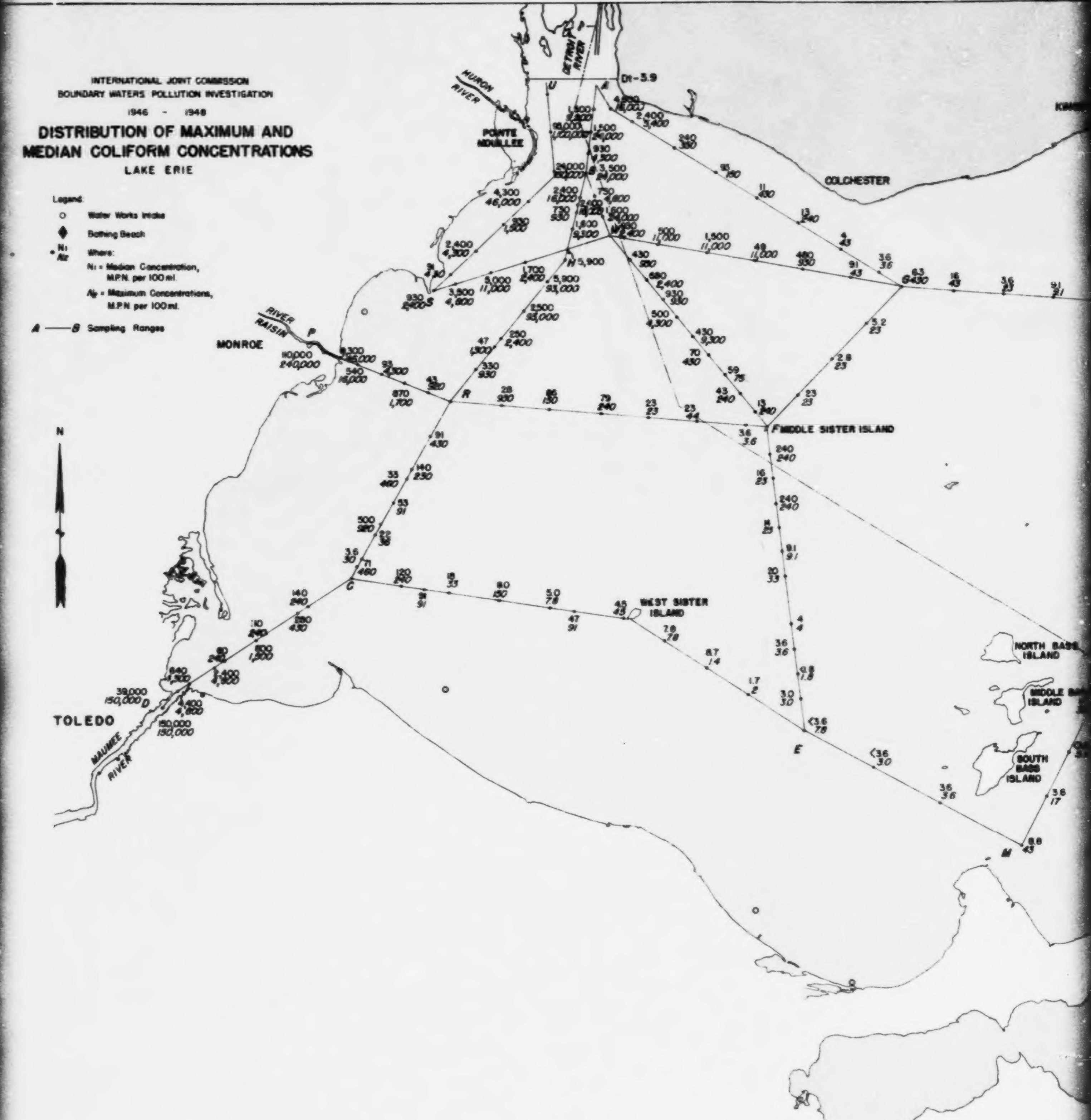

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948
DISTRIBUTION OF MAXIMUM AND MEDIAN COLIFORM CONCENTRATIONS
LAKE ERIE
Legend:
Water Works Intake
Bothing Beach
Where:
N₁ = Median Concentration, M.P.N. per 100 ml.
N₂ = Maximum Concentrations, M.P.N. per 100 ml.
A —— B Sampling Ranges
N
DETROIT RIVER
HURON RIVER
POINTE MOUILLEE
D1-3.9
COLCHESTER
RIVER RAISIN
MONROE
MIDDLE SISTER ISLAND
WEST SISTER ISLAND
NORTH BASS ISLAND
MIDDLE BASS ISLAND
SOUTH BASS ISLAND
TOLEDO
MAUMEE RIVER
U
S
H
P
R
C
D
E
F
G
M
Scale in Miles
1 0 1 2 3 4 5 6 7 8 9

Figure 11

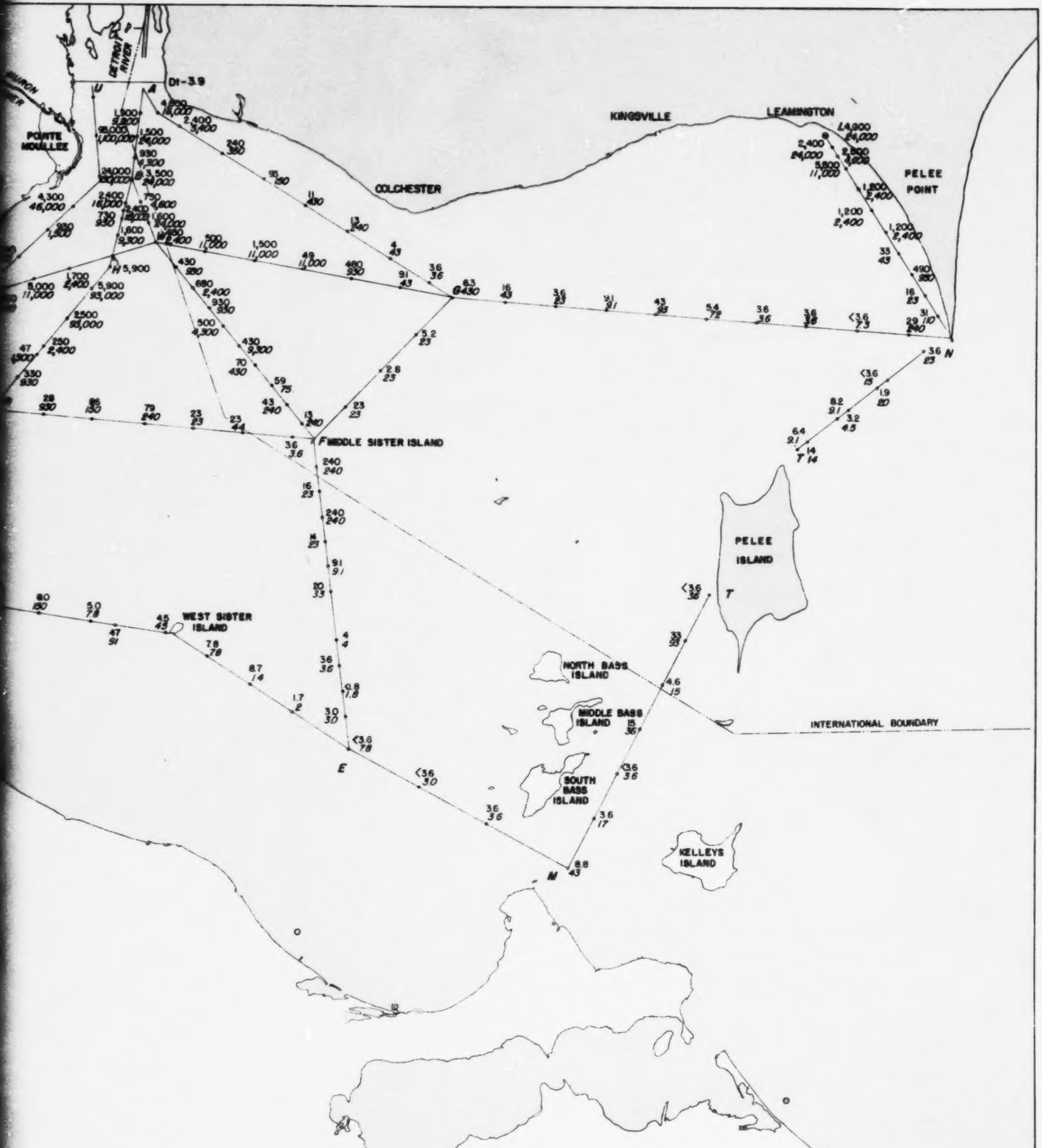

DETROIT RIVER
HURON RIVER
POINTE MOUILLEE
DI-3.9
U
A
B
H
W
G
F
E
M
N
T
KINGSVILLE
LEAMINGTON
COLCHESTER
PELEE POINT
MIDDLE SISTER ISLAND
WEST SISTER ISLAND
PELEE ISLAND
NORTH BASS ISLAND
MIDDLE BASS ISLAND
SOUTH BASS ISLAND
KELLEYS ISLAND
INTERNATIONAL BOUNDARY
Scale in Miles
1 0 1 2 3 4 5 6 7 8 9 10 11 12

Figure 11

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TABLE 22—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ERIE

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Oder, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
A-B Ship Channel, Detroit River Light to Bar Point	3.0(A)	Median	1,500	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	8.8	6	0.03	0.1	15.5	9.7	0.56	7	84	2	....	1	....	....	190	....
		Maximum	9,200	15	25	0.30	0.1	24.0	11.8	2.00	16	84	3	....	1	....	....	240	130
		Minimum	430	5.5	0	0	0.1	9.5	8.0	0.01	1.4	84	1	....	1	....	....	130	64
		No. of Samples	12	13	13	10	2	10	12	13	7	1	2	....	2	....	2	3	3
A-B Ship Channel, Detroit River Light to Bar Point	2.0	Median	1,500	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	8.3	2	0.01	0.10	13.5	10.0	1.2	5	....	2	....	1	....	....	150	64
		Maximum	24,000	12	12	0.04	0.1	22.5	11.8	5.60	13	....	2	....	1	....	....	170	78
		Minimum	230	5.0	0	0	0	9.5	7.8	0.20	0.9	....	1	....	1	....	....	120	50
		No. of Samples	11	11	11	8	2	8	10	11	5	....	2	....	2	....	2	2	2
A-B Ship Channel, Detroit River Light to Bar Point	1.0	Median	930	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	11	2	0.004	0.13	13.5	9.8	0.72	4.6	85	2	....	1	....	....	140	69
		Maximum	4,300	14	7	0.03	0.15	22.5	11.6	1.4	10	85	2	....	1	....	....	160	92
		Minimum	93	5.5	0	0	0.10	9.5	7.8	0	1.2	85	1	....	1	....	....	130	54
		No. of Samples	10	11	11	8	2	8	10	11	5	1	2	....	2	....	2	3	3
A-B Ship Channel, Detroit River Light to Bar Point	0.0(B)	Median	3,500	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	14	3	0.016	0.1	13.5	9.7	0.74	9	83	1	....	1	....	....	150	70
		Maximum	>24,000	22	12	0.06	0.1	22.5	11.7	1.40	18	83	1	....	1	....	....	150	82
		Minimum	430	6.4	0	0	0.1	9.5	7.3	0.20	1.7	83	1	....	1	....	....	140	60
		No. of Samples	12	12	13	9	2	8	12	13	6	1	2	....	2	....	....	3	3
U. S. West Shore opposite Bar Point to Stony Point	0.0(U)	Median	240,000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	20	0	0	....	16.5	8.1	....	....	....	....	....	....	....	....	....	....
		Maximum	240,000	20	0	0	....	16.5	8.1	....	....	....	....	....	....	....	....	....	....
		Minimum	240,000	20	0	0	....	16.5	8.1	....	....	....	....	....	....	....	....	....	....
		No. of Samples	1	1	1	1	....	1	1	....	....	....	....	....	....	....	....	....	....
	1.5	Median	93,000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	27	6	0.05	....	8.0	10.0	1.8	19	....	....	....	....	....	....	....	....
		Maximum	1,100,000	29	15	0.14	....	16.0	13.3	2.7	24	....	....	....	....	....	....	....	....
		Minimum	9,300	26	0	0	....	0	7.5	1.2	16	....	....	....	....	....	....	....	....
		No. of Samples	3	3	3	3	....	2	3	3	3	....	....	....	....	....	....	....	....
	3.0	Median	24,000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	39	10	0.14	....	16.5	9.9	1.7	20	....	....	....	....	....	....	....	....
		Maximum	150,000	50	16	0.18	....	16.5	13.4	2.7	23	....	....	....	....	....	....	....	....
		Minimum	21,000	32	0	0.06	....	16.5	7.8	1.1	16	....	....	....	....	....	....	....	....
		No. of Samples	3	3	3	3	....	1	3	3	3	....	....	....	....	....	....	....	....
	4.5	Median	4,300	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	36	7	0.15	....	8.0	10.7	2.6	18	....	....	....	....	....	....	....	....
		Maximum	46,000	44	12	0.28	....	16.5	13.2	3.1	23	....	....	....	....	....	....	....	....
		Minimum	430	24	0	0	....	0	8.7	1.6	14	....	....	....	....	....	....	....	....
		No. of Samples	3	3	3	3	....	2	3	3	3	....	....	....	....	....	....	....	....

TABLE 22—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ERIE—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
U. S. West Shore opposite Bar Point to Stony Point (Continued)	6.0	Median	930	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	29	4	0.01	....	8.0	11.0	3.2	22	....	....	....	....	....	....	....	....
		Maximum	1,500	36	7	0.04	....	16.0	13.5	2.7	29	....	....	....	....	....	....	....	....
		Minimum	230	22	0	0	....	0	9.3	1.7	16	....	....	....	....	....	....	....	....
		No. of Samples	3	3	3	3	....	2	3	3	3	....	....	....	....	....	....	....	....
	7.5	Median	2,400	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	32	6.0	0.10	....	8.0	10.6	1.22	16	....	....	....	....	....	....	....	....
		Maximum	4,300	45	12	0.26	....	16.0	13.4	1.6	20	....	....	....	....	....	....	....	....
		Minimum	30	19	0	0	....	0.0	9.2	1.1	13	....	....	....	....	....	....	....	....
		No. of Samples	3	3	3	3	....	2	3	3	3	....	....	....	....	....	....	....	....
	9.0	Median	91	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	26	2	0.01	....	9.0	10.7	1.6	17	....	....	....	....	....	....	....	....
		Maximum	430	30	5	0.04	....	16.5	13.8	2.0	19	....	....	....	....	....	....	....	....
		Minimum	39	23	0	0	....	0	8.7	1.2	16	....	....	....	....	....	....	....	....
		No. of Samples	3	3	3	3	....	2	3	3	3	....	....	....	....	....	....	....	....
	10.0(S)	Median	930	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	24	4	0.003	....	9.0	10.3	1.8	17	....	....	....	....	....	....	....	....
		Maximum	2,400	26	7	0.01	....	16.5	13.7	2.9	20	....	....	....	....	....	....	....	....
		Minimum	91	22	0	0	....	0	8.6	1.2	15	....	....	....	....	....	....	....	....
		No. of Samples	4	4	4	4	....	2	4	4	4	....	....	....	....	....	....	....	....
B-H-R-C Detroit River Light to West Channel Outer Buoy to Monroe Light to Toledo Harbor Light	1.0	Median	2,400	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	18	2	....	0.1	....	8.1	1.3	1.9	88	2	....	1	....	....	150	61
		Maximum	16,000	22	6	....	0.1	....	8.2	2.0	3.3	88	2	....	1	....	....	160	72
		Minimum	2,400	14	0	....	0.1	....	8.0	0.8	0.7	87	1	....	1	....	....	140	52
		No. of Samples	4	4	4	....	2	....	2	4	4	2	2	....	2	....	2	4	4
	1.5	Median	2,400	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	29	9	0.04	....	14.5	10.0	1.1	12	....	....	....	....	....	....	....	....
		Maximum	9,300	37	15	0.16	....	23.0	11.7	1.8	15	....	....	....	....	....	....	....	....
		Minimum	36	14	0	0	....	9.5	7.9	0.47	8	....	....	....	....	....	....	....	....
		No. of Samples	5	5	5	5	....	5	6	6	2	....	....	....	....	....	....	....	....
	2.0	Median	730	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	15	3	....	0.20	....	8.2	0.6	0.9	....	3	....	1	....	....	140	60
		Maximum	920	16	6	....	0.20	....	8.4	0.8	1.1	....	3	....	1	....	....	140	68
		Minimum	540	14	0	....	0.10	....	8.0	0.4	0.7	....	2	....	1	....	....	140	52
		No. of Samples	2	2	2	....	2	....	2	2	2	....	2	....	2	....	....	2	2
	3.0	Median	1,500	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	20	1	0.09	0.15	14.0	9.3	0.97	3.6	85	2	....	1	....	....	140	54
		Maximum	9,300	39	6	0.14	0.20	23.0	11.4	1.6	8	85	2	....	1	....	....	160	72
		Minimum	93	9	0	0	0.10	10.0	7.6	0.0	0.7	84	1	....	1	....	....	130	42
		No. of Samples	9	9	9	5	2	4	7	9	6	2	2	....	2	....	2	4	4

4.5	Median	5,900																
	Average		18	0	0.06	....	14.5	9.7	1.1	8	....	....	....	....	....	....	....	....
	Maximum	93,000	32	0	0.16	....	23.0	10.6	1.6	8	....	....	....	....	....	....	....	....
	Minimum	230	11	0	0	....	10.5	8.1	0.5	8	....	....	....	....	....	....	....	....
	No. of Samples	4	4	4	4	....	4	4	4	1	....	....	....	....	....	....	....	....
6.0	Median	2,500																
	Average		17	0	0.06	0.15	14.5	9.2	0.9	2.3	86	3	....	1	....	....	140	38
	Maximum	15,000	31	0	0.14	0.15	23.0	10.9	1.8	3.2	88	3	....	1	....	....	180	48
	Minimum	70	7.3	0	0	0.15	11.0	6.8	0.2	0.7	83	3	....	1	....	....	96	20
	No. of Samples	6	6	6	3	1	4	5	7	3	2	1	....	1	....	1	3	3
7.5	Median	750																
	Average		26	11	0.03	....	15.0	10.0	0.75	8	....	....	....	....	....	....	....	....
	Maximum	2,400	26	35	0.06	....	23.5	11.1	1.2	8	....	....	....	....	....	....	....	....
	Minimum	91	10	0	0.0	....	10.5	7.6	0.32	8	....	....	....	....	....	....	....	....
	No. of Samples	3	4	4	4	....	4	4	4	1	....	....	....	....	....	....	....	....
8.0	Median	47																
	Average		29	1	....	0.1	....	8.3	0.95	2.4	86	2	....	1	....	....	160	59
	Maximum	1,300	41	2	....	0.1	....	7.4	1.60	4.1	90	2	....	1	....	....	200	82
	Minimum	0	16	0	....	0.1	....	9.2	0.20	1.0	81	1	....	1	....	....	130	26
	No. of Samples	4	4	4	....	2	....	2	4	4	3	2	....	2	....	1	4	4
9.0	Median	330																
	Average		23	2	0.14	....	15.0	9.9	0.71	6	....	....	....	....	....	....	....	....
	Maximum	930	44	7	0.30	....	24.0	11.2	1.8	6	....	....	....	....	....	....	....	....
	Minimum	150	11	0	0.01	....	10.5	7.2	0.2	6	....	....	....	....	....	....	....	....
	No. of Samples	4	4	4	4	....	4	4	4	1	....	....	....	....	....	....	....	....
10.5(R)	Median	130																
	Average		26	0	0.10	0.10	17.0	9.7	1.11	6	89	2	....	1	....	....	160	59
	Maximum	1,600	38	0	0.24	0.10	24.5	11.3	1.60	8	90	2	....	1	....	....	200	72
	Minimum	11	12	0	0	0.10	10.0	7.9	0.66	2	87	2	....	1	....	....	120	32
	No. of Samples	8	8	8	5	1	5	6	8	5	3	1	....	1	....	....	3	3
12.0	Median	91																
	Average		24	0	0.05	....	15.0	10.5	1.22	8	....	....	....	....	....	....	....	....
	Maximum	430	29	0	0.16	....	24.0	11.4	1.40	8	....	....	....	....	....	....	....	....
	Minimum	43	19	0	0	....	10.0	8.8	0.85	8	....	....	....	....	....	....	....	....
	No. of Samples	3	3	3	3	....	3	3	3	1	....	....	....	....	....	....	....	....
13.5	Median	140																
	Average		26	0	0.02	....	17.0	9.8	1.2	10	....	....	....	....	....	....	....	....
	Maximum	230	28	0	0.04	....	24.0	11.2	1.3	10	....	....	....	....	....	....	....	....
	Minimum	43	23	0	0	....	10.5	8.3	1.1	10	....	....	....	....	....	....	....	....
	No. of Samples	2	2	2	2	....	2	2	2	1	....	....	....	....	....	....	....	....
14.0	Median	33																
	Average		21	0	....	0.1	....	9.0	1.1	4.3	84	....	....	1	....	....	160	60
	Maximum	460	26	0	....	0.1	....	9.0	1.6	7.5	89	....	....	1	....	....	180	75
	Minimum	2	13	0	....	0.1	....	9.0	0.4	1.0	78	....	....	1	....	....	140	52
	No. of Samples	3	3	3	....	1	....	1	3	3	3	....	....	1	....	....	3	3
15.0	Median	53																
	Average		21	0	0	....	17.5	10.8	2.2	11	....	....	....	....	....	....	....	....
	Maximum	91	26	0	0	....	24.5	11.4	3.2	11	....	....	....	....	....	....	....	....
	Minimum	15	16	0	0	....	11.0	10.3	1.1	11	....	....	....	....	....	....	....	....
	No. of Samples	2	2	2	2	....	2	2	2	1	....	....	....	....	....	....	....	....

TABLE 22—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ERIE—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
B-H-R-C Detroit River Light to West Channel Outer Buoy to Monroe Light to Toledo Harbor Light (Continued)	16.0	Median	500																
		Average	...	28	3	...	0.1	...	8.8	1.5	11	87	3	...	1	...	...	210	84
		Maximum	920	31	6	...	0.1	...	8.8	1.6	20	94	3	...	1	...	...	232	92
		Minimum	70	25	0	...	0.1	...	8.8	1.4	1.4	80	3	...	1	...	...	190	76
		No. of Samples	2	2	2	...	1	...	1	2	2	2	1	...	1	...	...	2	2
	16.5	Median	22																
		Average	...	16	4	0	...	18.0	10.2	1.4	10	...	...	...	...	...	...	...	...
		Maximum	36	24	8	0	...	24.5	11.5	1.7	10	...	...	...	...	...	...	...	...
		Minimum	7.2	11	0	0	...	10.5	8.9	1.1	10	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	2	2	2	1	...	...	...	...	...	...	...	...
	18.0	Median	3.6																
		Average	...	17	0	0	...	10.0	10.1	1.19	14	...	...	...	...	...	...	...	...
		Maximum	<30	22	0	0	...	24.5	11.3	1.50	14	...	...	...	...	...	...	...	...
		Minimum	3.6	11	0	0	...	10.5	8.9	0.88	14	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	2	2	2	1	...	...	...	...	...	...	...	...
	18.5(C)	Median	71																
		Average	...	23	4	0	0.15	24.5	9.3	1.6	19	91	1	...	1	...	...	220	74
		Maximum	460	25	20	0	0.15	24.5	10.0	2.5	29	100	1	...	1	...	...	260	88
		Minimum	<3.6	21	0	0	0.15	24.0	9.0	0.8	17	82	1	...	1	...	...	200	50
		No. of Samples	5	5	5	2	1	2	3	5	5	2	1	...	1	...	...	3	3
C-D Toledo Harbor Light to Toledo Coast Guard Station	20.5	Median	140																
		Average	...	19	3	0	...	24.0	10.1	2.4	29	...	...	...	...	...	...	...	...
		Maximum	240	20	5	0	...	24.5	10.8	2.7	31	...	...	...	...	...	...	...	...
		Minimum	43	18	0	0	...	23.5	9.5	2.1	27	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	2	2	2	2	...	...	...	...	...	...	...	...
	21.0	Median	280																
		Average	...	13	0	0.05	...	11.5	11.1	0.75	...	...	...	...	...	...	...	...	...
		Maximum	430	13	0	0.06	...	11.5	11.1	0.77	...	...	...	...	...	...	...	...	...
		Minimum	140	13	0	0.03	...	11.0	11.0	0.72	...	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	2	2	2	...	...	...	...	...	...	...	...	...
	22.5	Median	110																
		Average	...	21	6	0	0.3	24.0	10.0	2.7	22.0	96	3	...	1	...	...	210	68
		Maximum	240	23	24	0	0.3	24.0	10.7	5.1	37	99	3	...	1	...	...	230	86
		Minimum	17	19	0	0	0.3	23.5	8.6	0.4	1.4	93	3	...	1	...	...	190	50
		No. of Samples	4	4	4	2	1	2	3	4	4	2	1	...	1	...	1	2	2
	23.0	Median	800																
		Average	...	11	0	0.16	...	13.0	10.4	0.76	...	...	...	...	...	...	...	...	...
		Maximum	1,500	12	0	0.22	...	13.0	10.5	0.82	...	...	...	...	...	...	...	...	...
		Minimum	91	9	0	0.10	...	13.0	10.2	0.70	...	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	2	2	2	...	...	...	...	...	...	...	...	...

	24.5	Median	60	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average.	....	21	3	0	0.3	23.5	10.9	3.5	29	100	....	....	....	....	....	....	....
		Maximum	240	23	10	0	0.3	23.5	13.4	5.8	33	100	2	....	1	....	....	230	42
		Minimum	21	19	0	0	0.3	23.5	8.8	0.6	3	100	2	....	1	....	....	200	30
		No. of Samples	4	4	4	2	1	2	3	4	4	2	1	....	1	....	....	2	2
	25.0	Median	2,400	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	8.1	3	0.29	....	14.0	9.5	1.04	....	....	....	....	....	....	....	....	....
		Maximum	4,600	8.2	5	0.40	....	14.0	9.9	1.20	....	....	....	....	....	....	....	....	....
		Minimum	230	8.0	0	0.17	....	13.5	9.0	0.87	....	....	....	....	....	....	....	....	....
		No. of Samples	2	2	2	2	....	2	2	2	....	....	....	....	....	....	....	....	....
	26.5	Median	640	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	20	0	0.47	0.55	25.0	8.4	3.5	26	110	4	....	2	....	....	270	47
		Maximum	4,300	22	0	0.80	0.55	25.5	12.8	6.2	45	110	4	....	2	....	....	280	70
		Minimum	540	19	0	0.14	0.55	24.5	3.7	1.4	3	100	4	....	2	....	....	250	24
		No. of Samples	4	4	4	2	1	2	3	4	4	2	1	....	1	....	1	2	2
	27.0	Median	4,400	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	7.2	4	0.24	....	14.0	9.3	1.3	....	....	....	....	....	....	....	....	....
		Maximum	4,600	7.3	7	0.30	....	14.0	9.4	1.3	....	....	....	....	....	....	....	....	....
		Minimum	4,300	7.0	0	0.17	....	13.5	9.1	1.3	....	....	....	....	....	....	....	....	....
		No. of Samples	2	2	2	2	....	2	2	2	....	....	....	....	....	....	....	....	....
	27.5	Median	39,000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	22	10	0.85	0.40	25.5	3.2	2.0	19	115	4	....	1	....	....	270	110
		Maximum	150,000	28	40	0.90	0.40	26.0	4.7	3.40	32	120	4	....	1	....	....	280	130
		Minimum	1,600	18	0	0.80	0.40	25.0	1.8	0.58	2	110	4	....	1	....	....	260	88
		No. of Samples	4	4	4	2	1	2	3	4	4	2	1	....	1	....	1	2	2
	29.0(D)	Median	150,000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	14	0	0.44	0.40	15.5	6.0	2.7	2.1	130	4	....	1	....	....	320	90
		Maximum	150,000	26	0	0.50	0.40	15.5	7.4	2.8	2.1	130	4	....	1	....	....	320	90
		Minimum	5,400	7.8	0	0.38	0.40	15.0	4.0	2.5	2.1	130	4	....	1	....	....	320	90
		No. of Samples	3	3	3	2	1	2	3	3	1	1	1	....	1	....	1	1	1
	1.0	Median	4,600	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	35	3	0.003	0.10	21	8.8	0.78	5.2	84	1	....	1	....	....	190	120
		Maximum	16,000	65	8	0.01	0.10	24.0	10.5	1.20	10	84	1	....	1	....	....	230	150
		Minimum	930	13	0	0	0.10	14.0	7.8	0.26	1.1	84	1	....	1	....	....	150	84
		No. of Samples	5	5	5	3	1	3	3	4	4	1	1	....	1	....	1	2	2
A-G Detroit River East Channel end Buoy to Colchester Reef Light	2.0	Median	2,400	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	27	2	0.005	0.15	21.0	8.7	0.63	6	86	3	....	1	....	....	200	105
		Maximum	5,400	62	8	0.01	0.15	24.5	10.5	1.40	10	86	3	....	1	....	....	254	160
		Minimum	240	11	0	0	0.15	14.0	7.8	0.25	2	86	3	....	1	....	....	146	52
		No. of Samples	5	5	5	3	1	3	4	5	4	1	1	....	1	....	1	2	2
	4.0	Median	240	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	25	3	0.14	0.10	21.0	8.9	0.92	4.4	86	4	....	1	....	....	180	110
		Maximum	350	60	8	0.14	0.10	25.0	10.7	2.00	9	86	4	....	1	....	....	220	160
		Minimum	93	7.5	0	0	0.10	14.0	7.2	0.40	0.7	86	4	....	1	....	....	140	58
		No. of Samples	5	5	5	2	1	3	4	5	4	1	1	....	1	....	1	2	2
	6.0	Median	93	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	21	1	0.05	0.15	20.5	9.0	10.5	4	85	5	....	4	....	....	170	90
		Maximum	150	51	6	0.14	0.15	24.5	10.6	2.60	8	85	5	....	4	....	....	200	130
		Minimum	48	6.1	0	0	0.15	13.0	7.6	0.54	1	85	5	....	4	....	....	130	48
		No. of Samples	5	5	5	3	1	3	4	5	4	1	1	....	1	....	1	2	2

Table 22—Summary of Average Analytical Results—Lake Erie—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
A-G Detroit River East Channel end Buoy to Colchester Reef Light (Continued)	8.0	Median	11																
		Average		20	5	0.31	0.10	21.0	9.1	0.66	4	85	1		1			150	80
		Maximum	430	39	17	0.92	0.10	25.0	10.5	1.20	8	85	1		1			158	106
		Minimum	3.6	13	0	0	0.10	13.0	7.6	0.20	1	85	1		1			130	50
		No. of Samples	4	5	5	3	1	3	4	5	4	1	1		1		1	2	2
	10.0	Median	13																
		Average		19	6	0	0.10	20.5	9.2	0.99	4	87	1		1			140	74
		Maximum	240	32	25	0	0.10	25.0	10.4	2.20	7	87	1		1			140	100
		Minimum	<3.6	13	0	0	0.10	12.0	7.6	0.48	1	87	1		1			130	48
		No. of Samples	5	5	5	3	1	3	4	5	4	1	1		1		1	2	2
	12.0	Median	4.0																
		Average		19	3	0.01	0.15	20.5	8.8	0.94	4	85	1		1			130	62
		Maximum	43	27	7	0.04	0.15	25.0	10.1	1.50	8	85	1		1			130	92
		Minimum	2	14	0	0	0.15	12.0	7.2	0.20	1	85	1		1			120	32
		No. of Samples	5	5	5	3	1	3	4	5	4	1	1		1		1	2	2
	14.0	Median	3.6																
		Average		16	2	0		21.0	9.8										
		Maximum	3.6	16	12	0		25.0	10.1	1.40	7								
		Minimum	3.0	16	0	0		12.0	9.2	0.60	6								
		No. of Samples	3	3	3	2		3	3	3	2								
	15.0(G)	Median	6.3																
		Average		17	3	0	0.15	22.5	9.4	1.20	5.8	87	3		1			120	87
		Maximum	430	24	16	0	0.15	25.0	10.5	1.80	15	87	4		1			140	130
		Minimum	0	15	0	0	0.15	15.0	8.0	0.56	1.7	87	1		1			90	50
		No. of Samples	8	8	7	4	2	4	7	8	7	1	2		2		2	3	3
G-N Colchester Reef to Pelee Point Life Saving Station	17.0	Median	16																
		Average		15	0	0		25.0	9.4	1.14	9								
		Maximum	43	16	0	0		25.5	9.7	1.80	17								
		Minimum	3.6	14	0	0		24.5	8.8	0.58	4.0								
		No. of Samples	4	4	4	4		3	4	4	4								
	19.0	Median	3.6																
		Average		16	0	0		25.0	9.4	1.15	9								
		Maximum	23	16	0	0		25.0	9.7	2.1	16								
		Minimum	3.6	15	0	0		24.5	8.7	0.66	5								
		No. of Samples	4	4	4	4		3	4	4	4								
	21.0	Median	9.1																
		Average		15	0	0		25.0	9.5	0.85	10								
		Maximum	9.1	16	0	0		25.0	9.8	1.10	21								
		Minimum	<3.6	14	0	0		24.5	8.9	0.64	6								
		No. of Samples	4	4	4	4		3	4	3	4								

	23.0	Median	43																
		Average	...	16	0	0	...	25.0	9.4	0.95	10	...	...	...	...	...	...	...	...
		Maximum	93	16	0	0	...	25.0	9.7	1.20	20	...	...	...	...	...	...	...	...
		Minimum	<3.6	15	0	0	...	24.5	8.8	0.68	6	...	...	...	...	...	...	...	...
		No. of Samples	4	4	4	4	...	3	4	4	4	...	...	...	...	...	...	...	...
	25.0	Median	5.4																
		Average	...	16	0	0	...	25.0	9.2	0.84	11	...	...	...	...	...	...	...	...
		Maximum	7.2	18	0	0	...	25.5	9.3	1.0	24	...	...	...	...	...	...	...	...
		Minimum	<3.6	15	0	0	...	25.0	9.0	0.58	5	...	...	...	...	...	...	...	...
		No. of Samples	4	4	4	4	...	3	4	4	4	...	...	...	...	...	...	...	...
	27.0	Median	3.6																
		Average	...	17	1	0	...	25.0	9.1	0.99	10	...	...	...	...	...	...	...	...
		Maximum	3.6	19	4	0	...	25.5	9.2	1.2	18	...	...	...	...	...	...	...	...
		Minimum	<3.6	15	0	0	...	25.0	9.0	0.76	5	...	...	...	...	...	...	...	...
		No. of Samples	4	4	4	4	...	3	4	4	4	...	...	...	...	...	...	...	...
	29.0	Median	<3.6																
		Average	...	16	1	0	...	25.0	9.2	0.88	9	...	...	...	...	...	...	...	...
		Maximum	<3.6	18	4	0	...	25.5	9.4	1.1	16	...	...	...	...	...	...	...	...
		Minimum	<3.6	14	0	0	...	24.5	8.9	0.52	5	...	...	...	...	...	...	...	...
		No. of Samples	4	4	4	4	...	3	4	4	4	...	...	...	...	...	...	...	...
	31.0	Median	3.6																
		Average	...	17	0	0.001	...	25.0	8.9	0.74	8	...	...	...	...	...	...	...	...
		Maximum	7.3	20	0	0.006	...	25.5	9.3	0.96	14	...	...	...	...	...	...	...	...
		Minimum	<3.6	15	0	0	...	24.5	8.5	0.52	3	...	...	...	...	...	...	...	...
		No. of Samples	4	4	4	4	...	3	4	4	4	...	...	...	...	...	...	...	...
	33.0	Median	29																
		Average	...	17	3	0	...	25.0	8.8	0.71	7	...	...	...	...	...	...	...	...
		Maximum	240	18	10	0	...	25.5	9.7	0.91	10	...	...	...	...	...	...	...	...
		Minimum	3.6	16	0	0	...	24.5	8.1	0.40	4	...	...	...	...	...	...	...	...
		No. of Samples	4	4	4	4	...	3	4	4	4	...	...	...	...	...	...	...	...
B-W Detroit Light to East Channel end Buoy	1.0	Median	730																
		Average	...	12	3	0.01	0.15	13.0	10.0	0.74	7.6	82	4	...	4	...	...	220	76
		Maximum	4,600	23	7	0.05	0.15	13.0	10.7	1.40	17	82	4	...	4	...	...	310	78
		Minimum	240	6	0	0	0.15	12.5	8.0	0.34	2.6	82	4	...	4	...	...	130	74
		No. of Samples	7	6	6	4	1	3	6	7	3	1	1	...	1	...	1	2	2
	2.0	Median	1,600																
		Average	...	11	2	0.01	0.1	13.0	9.9	1.10	7	82	4	...	1	...	...	130	92
		Maximum	24,000	22	6	0.06	0.1	13.0	10.8	3.0	12	82	4	...	1	...	...	150	120
		Minimum	93	5	0	0	0.1	12.5	7.8	0.48	1.6	82	4	...	1	...	...	100	64
		No. of Samples	7	7	7	5	1	3	6	7	4	1	1	...	1	...	1	2	2
	3.0(W)	Median	930																
		Average	...	12	1	0.01	0.3	13.5	9.9	9.0	6	82	6.7	...	1	...	...	130	78
		Maximum	2,400	23	4	0.07	0.3	14.0	10.8	1.8	12	82	6.7	...	1	...	...	140	96
		Minimum	150	6	0	0	0.3	12.5	8.0	0.48	1.2	82	6.7	...	1	...	...	120	60
		No. of Samples	7	7	7	5	1	3	6	7	4	1	1	...	1	...	1	2	2
W-G Detroit River East Channel Outer Buoy to Colchester Reef Light	5.0	Median	500																
		Average	...	9	1	0.06	0.1	14.5	9.9	0.79	8	...	1	...	1	...	...	150	140
		Maximum	11,000	23	2.0	0.12	0.2	15.0	10.6	1.20	14	...	1	...	1	...	...	150	140
		Minimum	49	8	0	0	0	14.0	9.4	0.46	1.4	...	1	...	1	...	...	150	140
		No. of Samples	4	4	3	3	2	3	4	4	2	...	1	...	1	...	1	1	1

TABLE 22—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ERIE—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N₂ ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold: Raw No.	Raw Nature	Chlorinated No.	Chlorinated Nature	Taste	Total Solids ppm: Total	Volatile
W-G Detroit River East Channel Outer Buoy to Colchester Reef Light (Continued)	7.0	Median	1,500																
		Average	...	25	2	0.09	0.15	14.5	9.5	1.25	7	...	4	...	1	...	...	150	130
		Maximum	11,000	38	5	0.18	0.15	15.0	10.0	2.2	12	...	4	...	1	...	...	150	130
		Minimum	79	17	0	0	0.15	14.0	9.0	0.52	1.3	...	4	...	1	...	...	150	130
		No. of Samples	4	4	3	3	1	3	4	4	2	...	1	...	1	...	1	1	1
	9.0	Median	49																
		Average	...	22	4	0.06	0.2	14.0	9.6	0.79	6	...	2	...	1	...	...	130	130
		Maximum	>11,000	38	12	0.14	0.2	15.5	10.4	1.0	11	...	2	...	1	...	...	130	130
		Minimum	36	16	0	0	0.2	13.0	9.0	0.62	1.2	...	2	...	1	...	...	130	130
		No. of Samples	4	4	3	3	1	2	4	4	2	...	1	...	1	...	1	1	1
	11.0	Median	480																
		Average	...	18	3	0.01	0.1	14.5	9.9	0.81	7	...	2	...	1	...	...	150	120
		Maximum	930	25	10	0.04	0.1	15.0	10.4	1.2	13	...	2	...	1	...	...	150	120
		Minimum	<23	14	0	0	0.1	14.0	9.0	0.2	1.1	...	2	...	1	...	...	150	120
		No. of Samples	4	4	3	3	1	2	4	4	2	...	1	...	1	...	1	1	1
	13.0	Median	9.1																
		Average	...	16	8	0	0.15	14.5	10.1	1.18	7	...	1	...	1	...	...	110	110
		Maximum	43	17	13	0	0.15	15.0	10.5	2.0	11	...	1	...	1	...	...	110	110
		Minimum	3.6	14	0	0	0.15	13.5	9.4	0.68	1.8	...	1	...	1	...	...	110	110
		No. of Samples	4	4	3	3	1	2	4	4	2	...	1	...	1	...	1	1	1
W-F Detroit River East Channel Outer Buoy to Middle Sister Island	4.0	Median	430																
		Average	...	8.0	5.7	0	...	13.2	10.6	0.62	11	...	...	...	...	...	...	...	...
		Maximum	930	10	15	0	...	13.5	11.0	0.64	11	...	...	...	...	...	...	...	...
		Minimum	91	6.9	0	0	...	13.0	10.2	0.60	11	...	...	...	...	...	...	...	...
		No. of Samples	3	3	3	3	...	2	3	3	1	...	...	...	...	...	...	...	...
	5.0	Median	680																
		Average	...	13	0	0	0.20	14.5	10.0	0.90	4.1	82	1	...	1	...	...	150	91
		Maximum	2,400	16	0	0	0.20	14.5	10.8	1.40	8	82	1	...	1	...	...	180	130
		Minimum	350	10	0	0	0.20	14.5	8.6	0.60	1.6	82	1	...	1	...	...	120	52
		No. of Samples	5	5	4	3	1	2	4	5	3	1	1	...	1	...	1	1	1
	6.0	Median	930																
		Average	...	18	0.67	0.02	...	15.0	10.1	0.68	9	...	...	...	...	...	...	...	...
		Maximum	930	24	2	0.04	...	15.0	10.5	0.70	9	...	...	...	...	...	...	...	...
		Minimum	430	14	0	0	...	15.0	9.7	0.66	9	...	...	...	...	...	...	...	...
		No. of Samples	3	3	3	3	...	2	3	3	1	...	...	...	...	...	...	...	...
	7.0	Median	500																
		Average	...	16	0.50	0.01	0.10	15.0	9.9	1.16	4.2	82	1	...	1	...	...	155	110
		Maximum	4,300	20	2	0.04	0.10	15.0	11.0	2.40	8	82	1	...	1	...	...	180	150
		Minimum	43	11	0	0	0.10	15.0	8.6	0.64	2.1	82	1	...	1	...	...	130	66
		No. of Samples	5	5	4	3	1	2	4	5	3	1	1	...	1	...	1	2	2

	8.0	Median	430	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	18	2.3	0.01	....	15.0	10.5	0.97	11	....	....	....	....	....	....	....	....
		Maximum	9,300	19	7	0.04	....	15.5	11.0	1.10	11	....	....	....	....	....	....	....	....
		Minimum	23	17	0	0	....	14.5	10.0	0.86	11	....	....	....	....	....	....	....	....
		No. of Samples	3	3	3	3	....	2	3	3	1	....	....	....	....	....	....	....	....
	9.0	Median	70	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	15	3	0.07	0.1	15.0	10.4	1.54	6.0	84	1	....	1	....	....	150	100
		Maximum	430	18	12	0.02	0.1	15.0	11.2	2.80	13	84	1	....	1	....	....	170	140
		Minimum	23	12	0	0	0.1	15.0	9.2	0.95	1.9	84	1	....	1	....	....	130	60
		No. of Samples	5	5	4	3	1	2	4	5	3	1	1	....	1	....	1	2	2
	10.0	Median	59	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	19	0	0	....	14.8	10.8	1.10	13	....	....	....	....	....	....	....	....
		Maximum	75	26	0	0	....	15.0	11.1	1.20	13	....	....	....	....	....	....	....	....
		Minimum	<3.0	12	0	0	....	14.5	10.6	1.00	13	....	....	....	....	....	....	....	....
		No. of Samples	3	3	3	3	....	2	3	3	1	....	....	....	....	....	....	....	....
	11.0	Median	43	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	17	0	0	0.05	15.2	10.2	1.33	4.6	88	1	....	1	....	....	140	77
		Maximum	240	24	0	0	0.05	15.5	10.8	2.8	11	88	1	....	1	....	....	170	130
		Minimum	4	12	0	0	0.05	15.0	8.8	0.74	1.7	88	1	....	1	....	....	110	24
		No. of Samples	5	5	4	3	1	2	4	5	3	1	1	....	1	....	1	2	2
	12.0(F)	Median	13	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	16	1	0.003	0.13	15.5	9.6	1.74	3.8	86	2	....	1	....	....	155	83
		Maximum	240	25	6	0.01	0.20	16.0	11.0	5.4	11	86	3	....	1	....	....	210	110
		Minimum	4.5	10	0	0	0.10	15.0	7.6	0.6	1.1	85	1	....	1	....	....	150	100
		No. of Samples	7	6	6	3	3	2	6	7	4	2	3	....	3	....	3	3	3
G-F Colchester Reef Light to Middle Sister Island	17.0	Median	5.2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	17	3	0	0.08	20.0	9.4	1.6	2.6	87	3	....	1	....	....	135	76
		Maximum	<23	23	10	0	0.15	25.0	10.9	2.0	6	87	4	....	1	....	....	140	96
		Minimum	<1.8	14	0	0	0.1	15.0	8.0	1.2	1.1	87	1	....	1	....	....	130	56
		No. of Samples	4	5	4	2	2	2	4	5	4	1	2	....	2	....	2	2	2
	19.0	Median	2.8	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	16	4	0.013	0.15	20.0	9.3	1.3	3.0	87	1	....	1	....	....	125	63
		Maximum	<23	21	8	0.02	0.20	25.0	11.0	1.8	8	87	1	....	1	....	....	130	72
		Minimum	<1.8	12	0	0.006	0.10	15.0	7.8	1.0	0.9	87	1	....	1	....	....	120	54
		No. of Samples	5	5	4	2	2	2	4	5	4	1	2	....	2	....	2	2	2
	21.0	Median	23	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	14	4	0	0.15	25.0	8.4	1.3	3.2	86	2	....	1	....	....	200	60
		Maximum	23	18	8	0	0.20	25.0	9.0	1.8	8	86	3	....	1	....	....	260	70
		Minimum	<1.8	10	0	0	0.10	25.0	7.4	0.4	1.3	86	1	....	1	....	....	140	50
		No. of Samples	4	4	3	1	2	1	3	4	4	1	2	....	2	....	2	2	2
S-H Stony Point to Outer Buoy on Detroit River West Channel	4.5	Median	3,500	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	25	2	0.01	....	8.0	10.8	1.37	17	....	....	....	....	....	....	....	....
		Maximum	4,600	28	5	0.04	....	16.0	13.6	1.5	24	....	....	....	....	....	....	....	....
		Minimum	2,400	23	0	0	....	0	9.3	1.2	10	....	....	....	....	....	....	....	....
		No. of Samples	2	3	3	3	....	2	3	3	3	....	....	....	....	....	....	....	....
	6.0	Median	5,700	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		Average	....	27	9	0.09	....	8.2	10.9	1.70	20	....	....	....	....	....	....	....	....
		Maximum	11,000	37	10	0.26	....	16.5	13.2	2.4	28	....	....	....	....	....	....	....	....
		Minimum	430	20	7	0	....	0	9.0	1.3	13	....	....	....	....	....	....	....	....
		No. of Samples	3	3.	3	3	....	2	3	3	3	....	....	....	....	....	....	....	....

TABLE 22—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ERIE—Continued

Sampling Range and Location	Station (Miles)		Coliform M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
S-H Stony Point to Outer Buoy on Detroit River West Channel (Continued)	7.5	Median	1,700	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	26	5.7	0.09	...	8.2	10.9	1.87	19	...	...	...	...	...	...	...	...
		Maximum	2,400	37	10	0.26	...	16.5	13.4	2.50	25	...	...	...	...	...	...	...	...
		Minimum	930	20	0	0	...	0	9.2	1.10	18	...	...	...	...	...	...	...	...
		No. of Samples	2	3	3	3	...	2	3	3	3	...	...	...	...	...	...	...	...
L-N Leamington Municipal Pier to Pelee Point Life Saving Station	0(L)	Median	4,600	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	16	0	0.005	...	25.0	8.1	1.15	8.5	...	...	...	...	...	...	...	...
		Maximum	>24,000	16	0	0.01	...	25.0	8.5	1.20	9	...	...	...	...	...	...	...	...
		Minimum	4,600	16	0	0	...	25.0	7.8	1.10	8	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	2	2	2	2	...	...	...	...	...	...	...	...
	0.5	Median	2,400	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	16	0	0	...	25.0	8.6	1.25	8	...	...	...	...	...	...	...	...
		Maximum	>24,000	16	0	0	...	25.0	8.6	1.40	9	...	...	...	...	...	...	...	...
		Minimum	2,400	15	0	0	...	25.0	8.5	1.10	7	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	2	2	2	2	...	...	...	...	...	...	...	...
	1.0	Median	2,500	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	16	0	0	...	25.2	8.5	0.76	7	...	...	...	...	...	...	...	...
		Maximum	4,600	17	0	0	...	25.5	8.5	1.0	7	...	...	...	...	...	...	...	...
		Minimum	430	15	0	0	...	25.0	8.5	0.52	7	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	2	2	2	2	...	...	...	...	...	...	...	...
	2.0	Median	5,500	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	16	0	0	...	25.0	8.7	1.01	6.5	...	...	...	...	...	...	...	...
		Maximum	11,000	16	0	0	...	25.5	8.8	1.2	8	...	...	...	...	...	...	...	...
		Minimum	75	16	0	0	...	24.5	8.6	0.82	5	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	2	2	2	2	...	...	...	...	...	...	...	...
	3.0	Median	1,200	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	16	0	0	...	25.0	8.4	0.61	7	...	...	...	...	...	...	...	...
		Maximum	2,400	16	0	0	...	25.5	8.4	1.00	8	...	...	...	...	...	...	...	...
		Minimum	43	15	0	0	...	24.5	8.3	0.22	6	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	2	2	2	2	...	...	...	...	...	...	...	...
	4.0	Median	1,200	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	15	0	0	...	24.5	8.6	1.08	6	...	...	...	...	...	...	...	...
		Maximum	2,400	15	0	0	...	24.5	8.7	1.50	7	...	...	...	...	...	...	...	...
		Minimum	43	15	0	0	...	24.5	8.6	0.66	5	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	2	2	2	2	...	...	...	...	...	...	...	...
	5.0	Median	1,200	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	16	0	0	...	25.0	8.6	0.90	6.5	...	...	...	...	...	...	...	...
		Maximum	2,400	16	0	0	...	25.5	8.8	1.10	7	...	...	...	...	...	...	...	...
		Minimum	9.1	15	0	0	...	24.5	8.5	0.69	6	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	2	2	2	2	...	...	...	...	...	...	...	...

	6.0	Median	33															
		Average		15	5	0		25.0	8.5	0.60	7							
		Maximum	43	15	10	0		25.5	8.5	0.72	8							
		Minimum	23	15	0	0		24.5	8.5	0.48	6							
		No. of Samples	2	2	2	2		2	2	2	2							
	7.0	Median	490															
		Average		14	0	0		25.0	8.6	0.87	6.5							
		Maximum	930	15	0	0		25.5	8.6	1.10	7							
		Minimum	43	14	0	0		24.5	8.5	0.64	6							
		No. of Samples	2	2	2	2		12	2	2	2							
	8.0	Median	16															
		Average		16	3.5	0		25.0	8.8	0.80	7.5							
		Maximum	23	17	7	0		25.5	8.9	0.90	8							
		Minimum	9.1	16	0	0		24.5	8.6	0.70	7							
		No. of Samples	2	2	2	2		2	2	2	2							
	9.0(N)	Median	31															
		Average		16	0	0		24.8	8.9	1.79	6	90					155	59
		Maximum	110	18	0	0		25.0	10.0	6.80	7	92					160	64
		Minimum	1.4	15	0	0		24.5	8.2	0.44	1.7	88					150	54
		No. of Samples	7	7	7	5		4	5	7	7	2					2	2
T-N Lighthouse Point Pelee Island to Pelee Point Life Saving Station	0	Median	14															
		Average		18	0					0.90	5.4	88					175	56
		Maximum	14	21	0					1.40	7.5	88					190	62
		Minimum	13	15	0					0.40	3.3	87					160	50
		No. of Samples	2	2	2					2	2	2					2	2
	0.5	Median	6.4															
		Average		18	0	0		24.5	8.8	0.67	11							
		Maximum	9.1	21	0	0		24.5	9.2	0.80	20							
		Minimum	<3.6	16	0	0		24.5	8.5	0.50	6							
		No. of Samples	3	3	3	3		2	3	3	3							
	2.0	Median	3.2															
		Average		20	0					1.6	5.0	85					170	54
		Maximum	4.5	22	0					1.6	7.5	88					190	72
		Minimum	2	17	0					1.6	2.5	82					150	36
		No. of Samples	2	2	2					2	2	2					2	2
	2.5	Median	8.2															
		Average		17	7	0		25.0	8.9	0.89	7.3							
		Maximum	9.1	18	15	0		25.0	9.6	1.5	11							
		Minimum	<3.6	16	6	0		25.0	8.4	0.54	5							
		No. of Samples	3	3	3	3		2	3	3	3							
	4.0	Median	1.9															
		Average		18	0					1.90	6.2	87					150	51
		Maximum	2	21	0					2.00	10.2	88					160	62
		Minimum	1.8	14	0					1.80	2.2	86					140	40
		No. of Samples	2	2	2					2	2	2					2	2
	4.5	Median	<3.6															
		Average		16	0	0		24.7	8.9	0.68	6.7							
		Maximum	15	16	0	0		25.0	9.9	0.70	9							
		Minimum	<3.6	16	0	0		24.5	8.4	0.64	5							
		No. of Samples	3	3	3	3		2	3	3	3							

Table 22—Summary of Average Analytical Results—Lake Erie—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
T-N Lighthouse Point Pelee Island to Pelee Point Life Saving Station (Continued)	6.5	Median	3.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	15	0	0	...	25.0	9.1	0.88	7.7	...	...	...	...	...	...	...	...
		Maximum	23	15	0	0	...	25.5	9.9	1.10	11	...	...	...	...	...	...	...	...
		Minimum	3.6	14	0	0	...	24.5	8.5	0.72	6	...	...	...	...	...	...	...	...
		No. of Samples	3	3	3	3	...	2	3	3	3	...	...	...	...	...	...	...	...
R-P River Raisin Channel Outer Buoy to River Raisin Turning Basin	11.5	Median	43	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	26	3	0.032	0.15	21.3	9.0	2.12	5.4	84	6.7	...	...	...	...	155	79
		Maximum	920	36	8	0.06	0.15	24.5	10.5	2.40	10	84	6.7	...	1	...	...	170	92
		Minimum	23	17	0	0.006	0.15	15.5	7.6	0.94	1.1	84	6.7	...	1	...	...	140	66
		No. of Samples	5	5	5	3	1	3	4	5	4	1	1	...	1	...	1	2	2
	12.5	Median	870	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	30	2	0.017	0.15	21.3	8.9	2.11	6	89	6.7	...	1	...	...	160	75
		Maximum	1,700	38	8	0.04	0.15	24.5	10.2	4.60	10	89	6.7	...	1	...	...	180	100
		Minimum	11	22	0	0.004	0.15	15.5	8.2	0.78	1.6	89	6.7	...	1	...	...	140	50
		No. of Samples	5	5	5	3	1	3	4	5	4	1	1	...	1	...	1	2	2
	13.5	Median	93	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	30	2.4	0.018	0.15	21.3	8.4	1.84	7.2	92	5	...	1	...	...	190	82
		Maximum	4,300	35	10	0.05	0.15	24.5	9.0	3.6	13	92	5	...	1	...	...	200	98
		Minimum	21	26	0	0	0.15	15.5	8.0	0.92	1.9	92	5	...	1	...	...	180	66
		No. of Samples	5	5	5	3	1	3	4	5	4	1	1	...	1	...	1	2	2
	14.5	Median	540	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	30	6	0.023	73	21.3	8.4	1.47	9	100	14	...	6.7	...	...	190	130
		Maximum	16,000	34	30	0.06	73	24.5	9.5	2.60	19	100	14	...	6.7	...	...	210	170
		Minimum	62	27	0	0	73	15.5	7.5	0	2.1	100	14	...	6.7	...	...	170	92
		No. of Samples	5	5	5	3	1	3	4	5	4	1	1	...	1	...	1	2	2
	15.5	Median	9,300	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	14	6	0.03	...	21.8	4.0	4.1	38	...	...	...	...	...	...	...	...
		Maximum	46,000	18	10	0.09	...	26.0	8.5	5.8	39	...	...	...	...	...	...	...	...
		Minimum	9,300	9.2	0	0	...	15.5	1.4	>1.4	37	...	...	...	...	...	...	...	...
		No. of Samples	3	3	3	3	...	3	3	3	2	...	...	...	...	...	...	...	...
	16.5(P)	Median	110,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	16	35	0.005	...	25.0	1.1	6.2	33	...	...	...	...	...	...	...	...
		Maximum	>240,000	18	70	0.01	...	26.0	2.2	6.2	37	...	...	...	...	...	...	...	...
		Minimum	110,000	14	0	0	...	24.0	0	6.2	30	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	2	2	1	2	...	...	...	...	...	...	...	...
R-F River Raisin Channel Outer Buoy to Middle Sister Island	12.5	Median	28	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	13	1.5	0.01	0.10	19.5	9.2	1.89	3.6	84	1	...	1	...	...	125	74
		Maximum	930	18	6	0.02	0.10	24.0	10.1	3.00	7	84	1	...	1	...	...	130	88
		Minimum	22	9.7	0	0.	0.10	15.0	8.4	0.86	1.7	84	1	...	1	...	...	120	60
		No. of Samples	4	4	4	4	2	1	2	3	4	3	1	...	1	...	1	2	2

	14.5	Median	86																
		Average	....	11	1.5	0.03	....	19.5	9.2	1.52	5.4	....	2	....	1	....	....	110	70
		Maximum	150	12	6	0.1	....	24.0	10.5	3.40	9	....	2	....	1	....	....	110	70
		Minimum	4.5	10	0	0	....	15.0	8.6	0.76	1.9	....	2	....	1	....	....	110	70
		No. of Samples	4	3	4	3	....	2	3	4	2	....	1	....	1	....	1	1	1
	16.5	Median	79																
		Average	....	14	2	0	0.10	19.5	9.1	1.13	3.2	88	1	....	1	....	....	120	62
		Maximum	240	18	8	0	0.10	24.0	10.0	1.4	6	88	1	....	1	....	....	140	72
		Minimum	<1.8	9.1	0	0	0.10	15.0	8.0	1.0	1.7	88	1	....	1	....	....	100	52
		No. of Samples	4	4	4	2	1	2	3	3	3	1	1	....	1	....	1	2	2
	18.5	Median	23																
		Average	....	12	1.5	0	0.10	19.8	9.2	1.12	2.8	86	1	....	1	....	....	114	68
		Maximum	23	17	6	0	0.10	24.5	10.8	1.60	5	86	1	....	1	....	....	140	70
		Minimum	<1.8	9.8	0	0	0.10	15.0	8.2	0.70	1.2	86	1	....	1	....	....	88	66
		No. of Samples	4	4	4	2	1	2	3	4	3	1	1	....	1	....	....	2	2
	20.5	Median	23																
		Average	....	13	1.5	0.005	0.10	19.8	9.3	1.05	2.6	88	5	....	1	....	....	120	70
		Maximum	44	17	6	0.01	0.10	24.5	10.9	1.20	5	88	5	....	1	....	....	140	70
		Minimum	<1.8	8.9	0	0	0.10	15.0	8.0	0.98	1.1	88	5	....	1	....	....	100	70
		No. of Samples	4	4	4	2	1	2	3	4	3	1	1	....	1	....	1	2	2
	22.5	Median	3.6																
		Average	....	12	0	0	....	19.8	9.8	0.89	6	....	....	....	....	....	....	....	....
		Maximum	3.6	13	0	0	....	24.5	10.8	0.92	6	....	....	....	....	....	....	....	....
		Minimum	<3.0	10	0	0	....	15.0	8.9	0.86	6	....	....	....	....	....	....	....	....
		No. of Samples	2	2	2	2	....	2	2	2	1	....	....	....	....	....	....	....	....
C-K-E Toledo Harbor Light to West Sister Island to Niagara Reef Buoy	2.0	Median	120																
		Average	....	24	0	....	0.15	....	9.0	2.0	23	100	2	....	1	....	....	240	82
		Maximum	240	26	0	....	0.15	....	9.0	2.6	45	110	2	....	1	....	....	290	84
		Minimum	4.5	23	0	....	0.15	....	9.0	1.4	1.4	92	2	....	1	....	....	190	80
		No. of Samples	2	2	1	....	1	....	1	2	2	2	1	....	1	....	1	1	1
	3.0	Median	91																
		Average	....	24	0	0.015	....	17.2	10.6	1.28	11	....	....	....	....	....	....	....	....
		Maximum	91	26	0	0.03	....	24.0	11.2	2.0	11	....	....	....	....	....	....	....	....
		Minimum	<3.6	22	0	0	....	10.5	10.0	0.56	11	....	....	....	....	....	....	....	....
		No. of Samples	2	2	2	2	....	2	2	2	1	....	....	....	....	....	....	....	....
	4.0	Median	18																
		Average	....	25	0	....	0.15	....	9.6	1.1	15	94	3	....	1	....	....	220	83
		Maximum	33	26	0	....	0.15	....	9.6	1.6	28	100	3	....	1	....	....	250	88
		Minimum	2	24	0	....	0.15	....	9.6	0.6	1.1	88	3	....	1	....	....	190	78
		No. of Samples	2	2	1	....	1	....	1	2	2	2	1	....	1	....	1	2	2
	6.0	Median	8.0																
		Average	....	24	2.3	0.04	0.01	17.2	9.8	1.12	10	90	1	....	....	....	....	205	92
		Maximum	150	26	7	0.08	0.01	24.5	11.1	1.80	22	99	1	....	....	....	....	230	100
		Minimum	3.6	21	0	0	0.01	10.0	8.8	0.56	1.1	80	1	....	....	....	....	180	84
		No. of Samples	4	4	3	2	1	2	3	4	3	2	1	....	....	....	....	2	2
	8.0	Median	5.0																
		Average	....	23	0	....	0.10	....	8.6	0.70	9.2	90	2	....	1	....	....	200	82
		Maximum	7.8	28	0	....	0.10	....	8.6	0.80	17	96	2	....	1	....	....	240	92
		Minimum	2.3	18	0	....	0.10	....	8.6	0.60	1.4	84	2	....	1	....	....	160	72
		No. of Samples	2	2	1	....	1	....	1	2	2	2	1	....	1	....	1	2	2

TABLE 22—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ERIE—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Oder, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
C-K-E Toledo Harbor Light to West Sister Island to Niagara Reef Buoy (Continued)	9.0	Median	47																
		Average		20	2.5	0.03		17.2	10.0	1.09	6								
		Maximum	91	21	5	0.06		24.5	11.4	1.30	6								
		Minimum	3.6	20	0	0		10.0	8.7	0.88	6								
		No. of Samples	2	2	2	2		2	2	2	1								
	11.0(K)	Median	4.5																
		Average		20	0	0	0.10	24.5	8.6	1.22	3.5	84	2		1			160	62
		Maximum	4.5	24	0	0	0.10	24.5	9.0	1.4	6	86	2		1			180	80
		Minimum	<1.8	17	0	0	0.10	24.5	8.3	0.88	1.4	83	2		1			140	44
		No. of Samples	3	3	3	1	1	1	2	3	3	2	1		1		1	2	2
	13.0	Median	7.8																
		Average		20	0		0.10		8.8	1.20	3.5	84	2		1			170	68
		Maximum	7.8	24	0		0.10		8.8	1.40	5.5	85	2		1			190	82
		Minimum	<1.8	16	0		0.10		8.8	1.00	1.4	83	2		1			150	54
		No. of Samples	2	2	2		1		1	2	2	2	2		1		1	2	2
	15.0	Median	0.7																
		Average		19	0		0.1		9.4	1.7	3.8	86	3		1			175	71
		Maximum	1.4	22	0		0.1		9.4	2.2	5.2	86	3		1			200	88
		Minimum	0	16	0		0.1		9.4	1.2	2.5	86	3		1			150	54
		No. of Samples	2	2	2		1		1	2	2	2	1		1		1	2	2
F-E Middle Sister Island to Niagara Reef Buoy	13.0	Median	240																
		Average		19	16	0			10.6	1.7	9								
		Maximum	240	19	16	0			10.6	1.7	9								
		Minimum	240	19	16	0			10.6	1.7	9								
		No. of Samples	1	1	1	1			1	1	1								
	14.0	Median	15																
		Average		26	0		0.1		7.8	1.3	1.6	89	1		1			150	50
		Maximum	23	34	0		0.1		7.8	2.4	2.0	92	1		1			160	60
		Minimum	6.8	18	0		0.1		7.8	0.2	1.3	86	1		1			140	40
		No. of Samples	2	2	2		1		1	2	2	2	1		1			2	2
	15.0	Median	240																
		Average		22	25	0			10.1	1.5	14								
		Maximum	240	22	25	0			10.1	1.5	14								
		Minimum	240	22	25	0			10.1	1.5	14								
		No. of Samples	1	1	1	1			1	1	1								
	16.0	Median	14																
		Average		18	0		0.05		8.6	1.3	1.7	86	3		1			155	56
		Maximum	23	20	0		0.05		8.6	1.4	2.4	86	3		1			160	60
		Minimum	4.5	15	0		0.05		8.6	1.2	1.0	85	3		1			150	52
		No. of Samples	2	2	2		1		1	2	2	2	1		1		1	2	2

	17.0	Median	9.1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	22	0	0	...	...	10.3	1.2	13	...	...	...	...	...	...	...	...
		Maximum	9.1	22	0	0	...	...	10.3	1.2	13	...	...	...	...	...	...	...	...
		Minimum	9.1	22	0	0	...	...	10.3	1.2	13	...	...	...	...	...	...	...	...
		No. of Samples	1	1	1	1	...	...	1	1	1	...	...	...	...	...	...	...	...
	18.0	Median	20	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	18	0	...	0.05	...	8.0	2.3	1.8	84	3	...	1	...	...	145	61
		Maximum	33	21	0	...	0.05	...	8.0	3.4	2.5	84	3	...	1	...	...	160	64
		Minimum	6.8	16	0	...	0.05	...	8.0	1.2	1.0	84	3	...	3	...	...	130	58
		No. of Samples	2	2	2	...	1	...	1	2	2	2	1	...	1	...	1	2	2
	19.0	Median	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	20	0	0	...	...	10.2	1.1	12	...	...	...	...	...	...	...	...
		Maximum	...	20	0	0	...	...	10.2	1.1	12	...	...	...	...	...	...	...	...
		Minimum	...	20	0	0	...	...	10.2	1.1	12	...	...	...	...	...	...	...	...
		No. of Samples	...	1	1	1	...	...	1	1	1	...	...	...	...	...	...	...	...
	20.0	Median	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	17	0	...	0.1	...	8.8	1.5	2.1	86	2	...	1	...	...	165	64
		Maximum	4	18	0	...	0.1	...	8.8	1.6	2.9	87	2	...	1	...	...	170	76
		Minimum	<1.8	16	0	...	0.1	...	8.8	1.4	1.3	84	2	...	1	...	...	160	52
		No. of Samples	2	2	2	...	1	...	1	2	2	2	1	...	1	...	1	2	2
	21.0	Median	3.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	18	20	0	...	...	9.1	0.53	18	...	...	...	...	...	...	...	...
		Maximum	3.6	18	20	0	...	...	9.1	0.53	18	...	...	...	...	...	...	...	...
		Minimum	3.6	18	20	0	...	...	9.1	0.53	18	...	...	...	...	...	...	...	...
		No. of Samples	1	1	1	1	...	...	1	1	1	...	...	...	...	...	...	...	...
	22.0	Median	<1.8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	20	0	...	0.10	...	8.8	1.0	4.8	85	2	...	1	...	...	170	63
		Maximum	<1.8	22	0	...	0.1	...	8.8	1.2	6.7	87	2	...	1	...	...	190	66
		Minimum	<1.8	18	0	...	0.1	...	8.8	0.8	2.9	83	2	...	1	...	...	150	60
		No. of Samples	2	2	2	...	1	...	1	2	2	2	1	...	1	...	1	2	2
	23.0	Median	3.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	18	25	0	...	...	9.0	0.56	24	...	...	...	...	...	...	...	...
		Maximum	3.0	18	25	0	...	...	9.0	0.56	24	...	...	...	...	...	...	...	...
		Minimum	3.0	18	25	0	...	...	9.0	0.56	24	...	...	...	...	...	...	...	...
		No. of Samples	1	1	1	1	...	...	1	1	1	...	...	...	...	...	...	...	...
	17.0	Median	1.7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	20	0	...	0.1	...	8.8	3.8	6.0	88	4	...	1	...	...	180	70
		Maximum	2	22	0	...	0.1	...	8.8	6.4	9.0	92	4	...	1	...	...	200	84
		Minimum	1.4	17	0	...	0.1	...	8.8	1.2	2.9	85	4	...	1	...	...	160	56
		No. of Samples	2	2	2	...	1	...	1	2	2	2	1	...	1	...	1	2	2
	20.0(E)	Median	<3.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	20	0	0	0.1	24.5	9.0	1.0	11	85	4	...	1	...	...	185	75
		Maximum	7.8	23	0	0	0.1	24.5	9.1	1.2	23	86	4	...	1	...	...	200	88
		Minimum	<1.8	18	0	0	0.1	24.5	8.8	0.59	2.2	84	4	...	1	...	...	170	62
		No. of Samples	4	4	4	2	1	1	3	3	4	2	1	...	1	...	1	2	2
E-M Niagara Reef Buoy to Scott Point Shoal Flashing Buoy	23.0	Median	3.3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Average	...	18	5	0	...	25.0	8.9	0.97	15	...	...	...	...	...	...	...	...
		Maximum	<3.6	18	10	0	...	25.0	9.0	1.5	19	...	...	...	...	...	...	...	...
		Minimum	3.0	17	0	0	...	25.0	8.8	0.44	11	...	...	...	...	...	...	...	...
		No. of Samples	2	2	2	2	...	1	2	2	2	...	...	...	...	...	...	...	...

TABLE 22—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ERIE—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N ppm	Chlor. Dem. ppm	Temp. °C	D. O. ppm	B.O.D. 5 day ppm	Turbidity ppm	Alk. ppm	Threshold Odor, Cold				Taste	Total Solids ppm	
													Raw		Chlorinated				
													No.	Nature	No.	Nature		Total	Volatile
E-M Niagara Reef Buoy to Scott Point Shoal Flashing Buoy (Continued)	26.0	Median	3.6																
		Average	....	17	10	0	......	24.5	8.9	0.80	13	....	....	....	....	....	....	....	....
		Maximum	3.6	17	20	0	......	24.5	9.0	1.1	16	....	....	....	....	....	....	....	....
		Minimum	<3.6	17	0	0	......	24.5	8.8	0.50	10	....	....	....	....	....	....	....	....
		No. of Samples	2	2	2	2	......	1	2	2	2	....	....	....	....	....	....	....	....
	29.0(M)	Median	8.8																
		Average	....	18	4.5	0	......	24.5	8.9	0.74	16	....	....	....	....	....	....	....	....
		Maximum	43	19	18	0	......	24.5	9.8	0.86	29	....	....	....	....	....	....	....	....
		Minimum	3.6	16	0	0	......	24.5	8.2	0.50	8	....	....	....	....	....	....	....	....
		No. of Samples	4	4	4	4	......	2	4	4	4	....	....	....	....	....	....	....	....
M-T Scott Point Shoal Flashing Buoy to Pelee Island West Dock	2.0	Median	3.6																
		Average	....	18	0	0.002	......	24.5	9.1	1.31	12	88	....	....	....	....	....	150	54
		Maximum	17	20	0	0.006	......	24.5	10.0	2.2	27	88	....	....	....	....	....	150	54
		Minimum	0	16	0	0	......	24.5	8.6	0.85	3.3	88	....	....	....	....	....	150	54
		No. of Samples	5	4	5	3	......	2	3	5	4	1	....	....	....	....	....	1	1
	4.0	Median	<3.6																
		Average	....	18	0	0	......	24.5	9.1	1.8	11	92	....	....	....	....	....	185	58
		Maximum	<3.6	21	0	0	......	24.5	9.8	3.4	26	97	....	....	....	....	....	210	64
		Minimum	<1.8	16	0	0	......	24.5	8.8	0.84	2.6	88	....	....	....	....	....	160	52
		No. of Samples	5	5	5	3	......	2	3	5	5	2	....	....	....	....	....	2	2
	6.0	Median	15																
		Average	....	18	3	0	......	24.5	9.0	1.5	11	91	....	....	....	....	....	180	57
		Maximum	36	24	12	0	......	24.5	9.6	3.6	26	92	....	....	....	....	....	200	50
		Minimum	1.4	16	0	0	......	24.5	8.6	0.64	5.5	89	....	....	....	....	....	160	64
		No. of Samples	5	5	5	3	......	2	3	5	5	2	....	....	....	....	....	2	2
	8.0	Median	4.6																
		Average	....	18	0.4	0	......	24.5	9.1	1.16	10	90	....	....	....	....	....	185	56
		Maximum	15	21	2	0	......	24.5	9.8	1.6	21	91	....	....	....	....	....	200	56
		Minimum	1.4	16	0	0	......	24.5	8.5	0.78	6.7	90	....	....	....	....	....	170	56
		No. of Samples	5	5	5	3	......	2	3	5	5	2	....	....	....	....	....	2	2
	10.0	Median	33																
		Average	....	16	0	0	......	24.5	9.3	0.98	12	....	....	....	....	....	....	....	....
		Maximum	93	18	0	0	......	24.5	9.8	1.4	23	....	....	....	....	....	....	....	....
		Minimum	<3.6	15	0	0	......	24.5	8.7	0.63	7	....	....	....	....	....	....	....	....
		No. of Samples	4	3	3	3	......	2	3	3	3	....	....	....	....	....	....	....	....
	12.0(T)	Median	<3.6																
		Average	....	15	0	0	......	24.5	9.4	1.2	7	....	....	....	....	....	....	....	....
		Maximum	<3.6	15	0	0	......	24.5	9.4	1.2	7	....	....	....	....	....	....	....	....
		Minimum	<3.6	15	0	0	......	24.5	9.4	1.2	7	....	....	....	....	....	....	....	....
		No. of Samples	1	1	1	1	......	1	1	1	1	....	....	....	....	....	....	....	....

United States side due to the quantities added in the Trenton Channel area.

Biochemical oxygen demand results for sampling stations above the mouth of the Rouge River generally averaged less than 1 p.p.m. Below the Rouge River average results ranged up to about 4 p.p.m., with individual results up to 9 p.p.m. The average dissolved oxygen concentrations were generally above 8 p.p.m. Individual results as low as 4 or 5 p.p.m. were recorded at some of the sampling stations in the lower portions of the river.

Ammonia results generally followed the same distribution as the phenols. The waters above the Rouge River had very low concentrations while those below this tributary had a considerably higher ammonium content, especially near the United States shore. Average values in the lower reaches vary up to 0.41 p.p.m.

Turbidity results were somewhat higher than those found in the St. Clair River and Lake St. Clair. Results at a few locations were about 10 p.p.m. but the greater number of samples averaged between 15 and 20 p.p.m.

Alkalinity results were fairly constant, averaging about 80 p.p.m. The hydrogen-ion concentrations were also quite constant, varying between 7.5 and 8.0.

Oils were observed at a number of places in the Detroit River, but it was not feasible to determine the actual amounts by sampling. As in the St. Clair River objectionable conditions are created in many local areas by waste substances.

Lake Erie

The summary of average analytical results for samples taken in Lake Erie is presented in table 22 (see preceding pages 137 to 152). Samples were taken at the west end of the lake as far east as Pelee Island.

The distribution of maximum and median coliform concentrations is shown in figure 11 (follows page 136). In United States waters the worst bacteriological conditions were found from the mouth of the Detroit River to the area lying below Pointe Mouillee. Median values here varied up to 93,000 per 100 ml., while maximum results rose to 1,100,000 per 100 ml. High concentrations were also found at the mouths of the Raisin and Maumee Rivers, but this pollution became well diluted within distances of 4 to 6 miles into the lake.

In Canadian waters high coliform concentrations were found at the mouth of the Detroit River and in the vicinity of Leamington. Median results were obtained as high as 4,600 for the former and 5,500 for the latter, with a maximum value of over 24,000 per 100 ml. for each place. There is no indication that the results at Leamington are due to the Detroit River discharges. Pollution from the Detroit River is diffused in a fan-like pattern and is generally dissipated in a distance of 12 miles from the mouth. Waters in the central portion of the area sampled were generally of good bacterial quality.

Other analytical results indicated the same conditions as those shown by the bacteriological analyses.

Comparisons—1913 and 1946-1948 Results

In view of the fact that a number of sampling points were common to both investigations it is possible to make comparisons of the conditions then and now. Since the previous examination was essentially a bacteriological one it is feasible to compare the coliform results only. Table 23 shows some comparisons made at four significant ranges in the Lake Huron-Lake Erie section. These comparisons can be approximate only since averages were used in the 1913 survey and medians in the present one. The former tends to give greater weight to abnormal results. Furthermore, the 1913 results are probably high because the tests were "presumptive" only. The B. coli index of the 1913 results has been converted to the M.P.N. index by applying the factor of 2.4 to the former.

TABLE 23—AVERAGE COLIFORM RESULTS, 1913 AND 1946-1948

Location	M.P.N. per 100 ml.	
	1913	1946-1948
Lake Huron	5	5
St. Clair River		
Port Lambton—Roberts Landing (Range SR-13.7)	305	910
Detroit River		
At Peach Island (Ranges Dt-30.7e and Dt-30.8w)	8	46
At Bar Point (Range Dt-3.9)	4,220	12,200

This table reveals that the present bacterial load is three to four times greater than in 1913. At that time, the overall increase from Lake Huron to the mouth of the Detroit River was approximately 800 times as compared with a 3000-fold increase today. In spite of the sewage treatment provided in this interval the bacterial load at the outlet of the Detroit River is about 3 times greater than in 1913.

Supplementary Information on Pollution Effects

While the effects of pollution on these boundary waters is revealed chiefly by the analytical results on samples collected during the survey, supplementary material has been obtained from various sources. All this information has been studied in an effort to evaluate the effects of pollution.

Municipal Water Supplies

Special studies were made during this investigation to evaluate any public health threat or burden placed by pollution on the public water supplies of the communities bordering on the boundary waters. The specific nature as well as the extent of this pollution was studied. The procedure included routine sampling and analysis of the raw waters by the field staffs, and review of purification plant records for the years 1942-1947, inclusive. These activities were concentrated at the major water plants located in the Lake Huron-Lake Erie section. The plants were selected to show local conditions and also progressive changes in water quality from the upper to the lower reaches.

A summary of the analytical results of raw water samples collected by the field staffs is given in table 24. At five plants, taking water from the St. Clair River and Lake St. Clair, the median numbers of coliform bacteria varied from a minimum of 92 to a maximum of 930 per 100 ml. For the same five plants, however, individual samples varied from a low of 2 to a high of 35,000 M.P.N. These extremes are more indicative of the problems associated with purification of the water reaching these intakes than are the median values.

The coliform results of the raw water samples taken at the Detroit plant show a median coliform number of 4.5 and a maximum of 2,400 per 100 ml. The quality of this supply is due to the location of the intake structure at the head of Belle Isle. This intake is beyond the normal zone of shore pollution, and it receives water which has been subjected to sedimentation and other natural purification processes in passing through Lake St. Clair. It is, however, subject to the influence of wind conditions, unusual currents, and other related factors.

At Wyandotte and Trenton, taking water from the lower Detroit River, the median coliform numbers were each 15,000 per 100 ml. The concentration of pollution at these intake locations is shown by corresponding high maximum M.P.N. indices of 163,000 and 46,000, respectively.

The other laboratory analyses listed in table 24 tend to confirm the intensity of pollution and variable quality as indicated by the bacteriological results.

The operations and laboratory records of six major water purification plants were reviewed to ascertain what changes took place in the quality of the raw water supplies over a more extended period. Emphasis was given to taste and odor troubles. The history in the plants revealed sporadic occurences during the past 20 years. Not until early in 1944, however, did the intensity and characteristics of the tastes and odors become major problems in waterworks using the boundary waters as sources of supply.

Coliform results from the plant laboratory records for 1942-1947 are summarized in table 25 (see page 156). These data show relatively high coliform numbers in the raw water at Marine City, taking water from the St. Clair River, and at Mt. Clemens, from the upper Lake St. Clair. Marine City average coliform results, on water taken through a relatively short intake, are higher than those for Mt. Clemens. They reflect the influence of shore pollution from upstream communities. Although the yearly average results at Mt. Clemens decreased from 1942 to 1947, the variation in the quality, as indicated by the high maximum values, showed no corresponding reduction. The variation in the dis-

TABLE 24—SUMMARY OF AVERAGE ANALYTICAL RESULTS FOR MUNICIPAL INTAKE SAMPLES

I. J. C. Field Data, 1946-1948

Municipality	Mileage Index No.		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_3 ppm	Chlor. Dem. ppm	D.O. ppm	B.O.D. 5 day ppm	pH	Alkalinity ppm	Turbidity ppm	Odor-Cold Threshold No.
Marysville.....	SR-31.2	Median...........	130	......	......	......	......	......	......	......	......	......	......
		Average.........	....	6.0	1	0.46	......	......	......	7.4	82	......	4.8
		Maximum.........	1,200	11	4	0.48	......	......	......	7.7	86	......	16
		Minimum.........	19	3.9	0	0	......	......	......	7.0	78	......	2
		No. of Samples....	23	8	8	8	......	......	......	8	8	......	8
St. Clair.......	SR-25.5	Median...........	320	......	......	......	......	......	......	......	......	......	......
		Average.........	....	5.8	1	0.16	0.7	......	......	7.3	79	......	5
		Maximum.........	1,300	7.8	2	0.42	1.1	......	......	7.6	84	......	16
		Minimum.........	190	2.6	0	0	0.6	......	......	6.9	74	......	2
		No. of Samples....	18	6	6	6	6	......	......	6	6	......	6
Marine City...	SR-17.7	Median...........	790	......	......	......	......	......	......	......	......	......	......
		Average.........	....	10	2	0.03	0.49	11.1	1.0	7.6	81	13	1
		Maximum.........	35,000	20.7	78	0.46	2.39	13.1	3.7	8.1	91	67	4
		Minimum.........	49	6.1	0	0	0.5	6.3	0	7.0	27	3	0
		No. of Samples....	153	38	48	29	44	29	30	38	38	16	33

Table 24—Summary of Average Analytical Results for Municipal Intake Samples—Continued

Municipality	Mileage Index No.		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Chlor. Dem. ppm	D.O. ppm	B.O.D. 5-day ppm	pH	Alkalinity ppm	Turbidity ppm	Odor-Cold Threshold No.
Mt. Clemens	Lake St. Clair Range SW-4.2	Median	930	......	......	......	......	......	......	......	......	......	......
		Average	......	9.4	8	0.14	0.43	11.1	1.4	7.6	91	38	3.5
		Maximum	18,000	32	264	0.5	1.35	13.3	13.0	8.7	130	122	16
		Minimum	<32	5.1	0	0	0.23	6.2	0.1	6.6	46	8	0
		No. of Samples	183	72	97	66	57	58	62	72	72	20	58
Grosse Pte. Farms	Lake St. Clair Range I-II-4.0	Median	92	......	......	......	......	......	......	......	......	......	......
		Average	......	8.0	2	0.03	0.38	11.3	1.8	7.6	85	41	1.0
		Maximum	16,000	16	22	0.40	0.80	13.8	2.6	8.0	99	43	10
		Minimum	1.9	5.0	0	0	0.19	6.0	0.3	7.3	76	2	0
		No. of Samples	144	34	49	28	37	28	28	35	36	9	37
Detroit	Dt-29.2	Median....	4.5	......	......	......	......	......	......	......	......	......	......
		Average...	......	7.3	1.0	0.03	0.30	11.0	0.63	7.6	83	11	1
		Maximum	2,400	27	30	0.46	0.95	13.8	2.2	8.5	100	75	4
		Minimum	0.63	4.7	0	0	0.10	5.8	0	7.3	74	2	0
		No. of Samples	441	73	98	60	74	76	77	73	73	29	72
Wyandotte	Dt-14.6	Median....	15,000	......	......	......	......	......	......	......	......	......	......
		Average...	......	19	5.9	0.05	0.39	10.9	2.0	7.6	82	13	3
		Maximum	163,000	90	50	0.50	0.80	13.14	8.0	8.0	100	55	20
		Minimum	4,300	5.9	0	0	0.3	6.1	0	7.3	80	5	0
		No. of Samples	220	55	75	39	36	58	62	47	47	33	35
Trenton	Dt-9.5	Median	15,000	......	......	......	......	......	......	......	......	......	......
		Average	......	69	33	......	......	12.0	6.6	8.3	93	......	5
		Maximum	46,000	96	76	......	......	13.5	9.1	9.2	110	......	16
		Minimum	910	26	0	......	......	9.2	2.2	7.5	84	......	0
		No. of Samples	35	12	12	......	......	11	12	12	12	......	12

charge of sewage pollution from the Clinton River, located a few miles above this waterworks intake, appears to be primarily responsible for these high maximum coliform counts.

The effects of the natural purification agencies in Lake St. Clair are evident from the lower coliform numbers in the raw water supplies of Grosse Pointe Farms and Highland Park. These two plants take water from a common intake point, located 2,500 feet offshore, approximately midway between the mouth of the Clinton River and the head of the Detroit River. Still lower numbers of coliform bacteria are found in the raw water received at Detroit. This further demonstrates the beneficial effects of detention and dilution taking place in Lake St. Clair.

The water taken by Wyandotte from the lower Detroit River has the highest coliform number of any public water supply located on these boundary waters. This is not surprising since the intake is located below discharges from the concentrated industrial areas and sewer outlets in the Detroit and Rouge Rivers, and, because of a break in the intake line, water is drawn from the zone of gross shore pollution. Similar water quality prevailed at the downstream city of Trenton, Michigan, which condition forced the abandonment, in 1943, of that supply in favor of service from the Detroit system.

Tastes and odors have been irritating problems in the municipal water supplies of this section. Reliable records are not available over a period of years. Routine tests were run on few of the raw supplies prior to 1945, reliance being placed on the presence or absence of tastes in the treated water and on consumer complaints.

It is known that tastes and odors have been present in the raw water sporadically for several years. In most cases the treatment plants were successful in coping with this problem. In early 1944, tastes in the chlorinated water became more frequent and more persistent. Such condition was acute in the period 1944 to 1947. This would indicate either an increased intensity of taste producing substances or the introduction of new compounds. The situation became so pronounced that it was an important factor in prompting this investigation.

In the St. Clair River and Lake St. Clair area tastes have been reported in most water supplies, with the exception of Port Huron and Sarnia. They have been more acute at Marine City, Mt. Clemens, and Detroit on the United States side. On the Canadian side all water supplies below Sarnia have experienced tastes. Worst conditions occurred at Wallaceburg in February 1946.

At Mt. Clemens, the first specific occurrence of chlorophenolic tastes was recorded in January 1944. During the remainder of that year and for 1945 and 1946 no such tastes were reported on the finished water. In January and March 1947 severe tastes were reported again. Faint tastes were noted in December 1947 and unusually severe tastes in January and February 1948. Routine taste tests on the chlorinated raw water were instituted at this plant in January 1948. No methods of taste control tried there have as yet proved completely effective. A review of data from the Mt. Clemens water filtration plant, which has its source of supply located in Lake St. Clair about five miles below the mouth of the Clinton River, indicates a close association between the diversion of storm flows into Red Run and Clinton River and water treatment difficulties at this plant.

In Detroit, the first major taste occurrence in the chlorinated raw water was experienced in May 1944. During the balance of that year there were occurrences of chlorophenolic tastes on 76 days, ranging from very faint to strong. Sixteen of these were reported as strong or definite. For 1945, out of 43 days of reported occurrences, 9 were strong or definite. In 1946 tastes were noted on 47 days, of which 12 were strong or definite. The total occurrences in 1947 were 13 days, with 3 of these being strong or definite. In 1948 the total was 9, of which 6 were strong or definite. Four of these strong tastes, in early December 1948, coincided with an accidental spill of phenol in the St. Clair River.

In Windsor, a very objectionable medicinal taste occurred in December 1930 in the water supplied to the consumers. In July 1937 and April 1940 similar tastes were noted. Some evidence of taste was detected in 1944, coincident with the Detroit experience, but the chloramine treatment was effective in reducing this taste to an acceptable degree. No taste occurrences in the treated water were reported in 1945. Routine tests on chlorinated raw water were not developed to a satisfactory point until late in 1945. Taste occurrences in 1946 totalled 8, of which 2 were more persistent. On February 20th a taste occurrence was common to both Detroit and Windsor. Wind directions on the 19th were E-NE and on the 20th were W-NW. This taste was preceded by a severe occurrence at Wallaceburg on February 15. In 1947, Windsor reported eight taste occurrences in February and March, one of which was a trace only. In 1948, the total was 6, all of which occurred in December, about a week later than the tastes at Detroit.

These records reveal that a greater number of taste occurrences were reported at Detroit than at Windsor. The number of such instances has declined; in Detroit, from a high of 76 in 1944 to a low of 9 in 1948.

In the lower Detroit River the records are not specific or complete, but it is known that frequent taste occurrences have been experienced for many

TABLE 25—SUMMARY OF COLIFORM RESULTS, IN M.P.N. PER 100 MILLILITERS

Data From Plant Laboratory Records

Year — Municipality	Marine City	Mt. Clemens	Grosse Pointe Farms	Highland Park	Detroit	Wyandotte
Source of Supply	St. Clair R.	L. St. Clair	L. St. Clair	L. St. Clair	Upper Detroit R.	Lower Detroit R.
1942						
Yearly Average	3,394	3,295	762	504	97	19,878
Maximum Daily Average	24,000	240,000	....	....	237	240,000
1943						
Yearly Average	4,475	3,385	569	700	201	16,120
Maximum Daily Average	24,000	240,000	....	....	1,102	240,000
1944						
Yearly Average	1,576	719	304	316	60	21,155
Maximum Daily Average	11,000	24,000	24,000	13,265	144	1,100,000
1945						
Yearly Average	2,167	510	226	290	115	21,627
Maximum Daily Average	11,000	>24,000	4,600	7,800	350	1,000,000
1946						
Yearly Average	5,128	1,622	456	740	212	23,657
Maximum Daily Average	11,000	240,000	11,000	8,350	1,196	1,110,000
1947						
Yearly Average	5,029	1,107	416	800	100	24,885
Maximum Daily Average	11,000	110,000	4,600	10,765	710	110,000

years at Wyandotte and to a lesser extent at Amherstburg.

Taste Examinations of Boundary Waters

In 1946, prior to this investigation, three taste surveys were made by water works officials of Detroit and Windsor. These studies were precipitated by the onset of tastes and odors in the Detroit water supply. This involved sampling of the waters of Lake St. Clair and St. Clair River to Sarnia and Port Huron. The water was first chlorinated and then examined for chlorophenolic tastes. It was found that tastes were traceable through Lake St. Clair and the Chenal Ecarte into the upper St. Clair River.

A special taste study was also undertaken by the field staffs on September 25 and 26, 1946 in connection with a taste occurrence at the Detroit water works. Samples were taken of the river and lake waters at various points, beginning at the Detroit intake lagoon at the head of Belle Isle and proceeding upstream as far as Port Huron and Sarnia. It was found that tastes were detectable at this time in the lake and into the upper St. Clair River.

Bathing Beaches

Since 1932, when the Michigan Stream Control Commission made a coastline pollution survey of the waters on the United States side from Lake Huron to Lake Erie, it has been generally known that these waters are either questionable or unsuitable for swimming. Periodic water tests and sanitary surveys at the organized bathing areas show the sanitary quality of the waters to be highly variable. This is influenced by many conditions such as wind, water currents, combined sewer overflows, and inadequate sanitary facilities. During more recent years the local health authorities have attempted some control over bathing beaches in their respective jurisdictions. The public demand, however, has dictated a less drastic action than the complete prohibition of these waters for swimming.

The Grosse Pointe communities, which maintain municipal beaches along the westerly shore of Lake St. Clair, have similarly recognized the danger of using the lake waters indiscriminately. The results on daily samples collected at the municipal beach of Grosse Pointe Farms may be taken as indicative of the water quality at this area. Using an M.P.N. index of 2,400, adopted by the Great Lakes Board of Public Health Engineers and recognized by others as the upper limit of tolerable bacterial pollution for bathing waters, it was found that this value was exceeded 19 percent of the time during the season of June, July, and August 1948. These coliform results, combined with the known presence of pollution from adjacent sources, resulted in closing the beaches to bathers for a total of seven days during that summer season.

To insure protection for its citizens, Grosse Pointe Park has enclosed an area in the lake with a concrete wall and maintains chlorination of the confined waters. Tests of this water have consistently shown low coliform concentrations, but this degree of protection has involved the spending of a considerable sum of public funds for the initial structure and for operation and maintenance.

There are numerous bathing areas spotted along the west shore of Lake St. Clair from Point Huron to Gaukler Point. The cluster of bathing beaches located within the immediate vicinity of the Nine Mile Drain has been of concern to local health authorities. Heavy shore pollution is indicated in tests made by the Macomb County Health Department during the summer of 1948. Samples at four local beaches showed high or excessive coliform numbers at two of the beaches in 50 percent of the samples taken, and water at the other two beaches unsuitable for bathing 30 percent and 25 percent of the time, respectively. These beaches were closed during the summer of 1946 but were opened the following seasons, subject to control by the local health officer. Epidemiological data in regard to local water-borne diseases are meager. Case histories of some typhoid patients in the city of Detroit in 1944 pointed strongly to infections contracted at the beaches adjacent to the Nine Mile Drain.

Pollution of the waters along the shores of the Detroit River has been demonstrated over a number of years. In 1941, the first action which recognized the unsuitability of the bathing waters surrounding Bois Blanc Island resulted in the voluntary closing of that beach. In 1944, the city of Detroit, by ordinance, prohibited swimming along its entire waterfront. The condition of these waters left no alternative. In spite of this voluntary action and prohibiting regulation there is considerable swimming in the Detroit River. During the hot summer days many persons, who do not have access to clean and safe swimming facilities, use these waters with compelte disregard of the proximity of sewer outlets and industrial waste drains.

There remain at present only two recognized bathing beaches in the Detroit River. One beach is located on the west shore of Belle Isle. The other is in the same locality on the Canadian shore. Sanitary control has been exercised over the Belle Isle beach by the Detroit Health Department since 1925. The coliform numbers, reported as Phelps Index, show a yearly median of less than 100 organisms per 100 ml. Occasional maxima of 1000 for individual samples have been reported.

Although the waters at the Belle Isle beach have been relatively free of bacterial pollution there have been occasions when the beach was closed to bathers. Pollution in the form of floating oil and sludge has crossed the channel, under certain wind conditions, from the mouth of Conner Creek, opposite Belle Isle on the United States shore. This beach has been closed for periods averaging five to seven days each season.

Fish and Wild Life

The effects of pollution are further revealed in many reported cases of the destruction of fish and ducks. This has been attributed to the presence of chemical poisons and oils. These occurrences have been most common in the lower Detroit River area.

Detroit Sewage Treatment Plant

In the evaluation of pollution it was necessary to determine what effect the sewage treatment plant of the city of Detroit has had upon the boundary waters. The significance of this plant is apparent when it is considered that it receives the wastes from a population of 2,200,000 and discharges an average of 350 M.G.D. (U. S.) of partially treated sewage into a part of the Detroit River already burdened by domestic and industrial wastes entering from upstream sources and from the Rouge River.

The information for this study was derived from an analysis of operating records of the Detroit sewage treatment plant, phenol tests of plant influent and effluent by the field staffs, and analytical results on river samples. Emphasis was placed on a comparison of the bacteriological quality of the river water before and after the installation of these works in 1940.

The Detroit plant effluent contained an average coliform concentration of 1,210,000 M.P.N. per 100 ml., based on 1946 and 1947 operating records. Other constituents in the effluent averaged: suspended solids 99 p.p.m., volatile suspended solids 70 p.p.m., ammonia (limited records) 18 p.p.m., and B.O.D. 63 p.p.m. The plant removed 55 percent of the suspended solids and 46 percent of the B.O.D. Chlorination satisfied 63 percent of the chlorine demand of the final effluent. It was necessary to suspend chlorination for 10 percent of this time because of slugs of pickling liquor. The operating policy was to satisfy 100 percent of the chlorine demand in the summer months and 60 percent for the rest of the year. It was stated to be difficult to maintain this policy because of the rapid fluctuation in chlorine demand and the variable flow rates.

Special phenol studies were conducted by the field staffs during the period of May 2 to 10, 1949. Analyses were made on samples collected at 30 minute intervals and composited at 3 hours and 24 hours. The average 24-hour phenol figure for the effluent was 150 p.p.b. when all known sources of phenol were contributing, including South Eastern Oakland County pumping station. Maximum values occurred between 6 and 9 A. M. each day. The highest figure for any 3-hour composite sample was 380 p.p.b. Removal of phenols in passing through the sewage plant varied from 5 to 33 percent.

Figure 12 shows the coliform results at range Dt-20.6, located approximately 1.2 miles above the sewage treatment plant outlet. The data, from the city of Detroit records, indicate the quality of the river water at this range before and after the advent of sewage collection and treatment. The coliform concentration in the Detroit River, within 300 to 600 feet of the United States shore, was approximately 10 times greater before sewage treatment than after. This reduction can be attributed to the interception of numerous raw sewage outfalls by the main trunk sewer leading to the sewage treatment plant. There was little or no change in the quality of the water at mid-stream.

Figure 13 presents the coliform concentrations at range Dt-19.0 nearly one-half mile below the treatment plant outlet. The Detroit records show that, within 300 feet of the United States shore, the results at this range before treatment were about the same or somewhat higher than after treatment. From this point to a distance of 900 feet from shore, the coliform concentration after sewage treatment is significantly less than before. In contrast, coliform results found by the field staffs show lower coliform numbers, than before treatment, to a point 600 feet from the United States shore but higher values across the remainder of the river. All data, however, follow the same general trend in concentrations.

The improvement brought about by the Detroit sewage treatment plant is partly offset by the heavy bacterial load introduced from the Rouge River. Coliform results of sampling at several locations further below the treatment works outlet show a relative improvement in the quality of the Detroit River water since the operation of the plant. Chlorination of the plant effluent began on July 3, 1940. At the Trenton Channel toll bridge (range Dt-12.0w) the coliform index for 1939, prior to sewage treatment, was 62,270, and in 1941, after treatment, the index was 20,240 per 100 ml. The field staffs' data showed an average index of 15,500 for this range in 1946-1948. At range Dt-9.3e the coliform index for 1938-1939 averaged 20,000 from the Grosse Ile shore to the International Boundary. In 1940-1946 it averaged 7,500, and in 1946-1948 the average for the samples taken by the field staffs was 4,000.

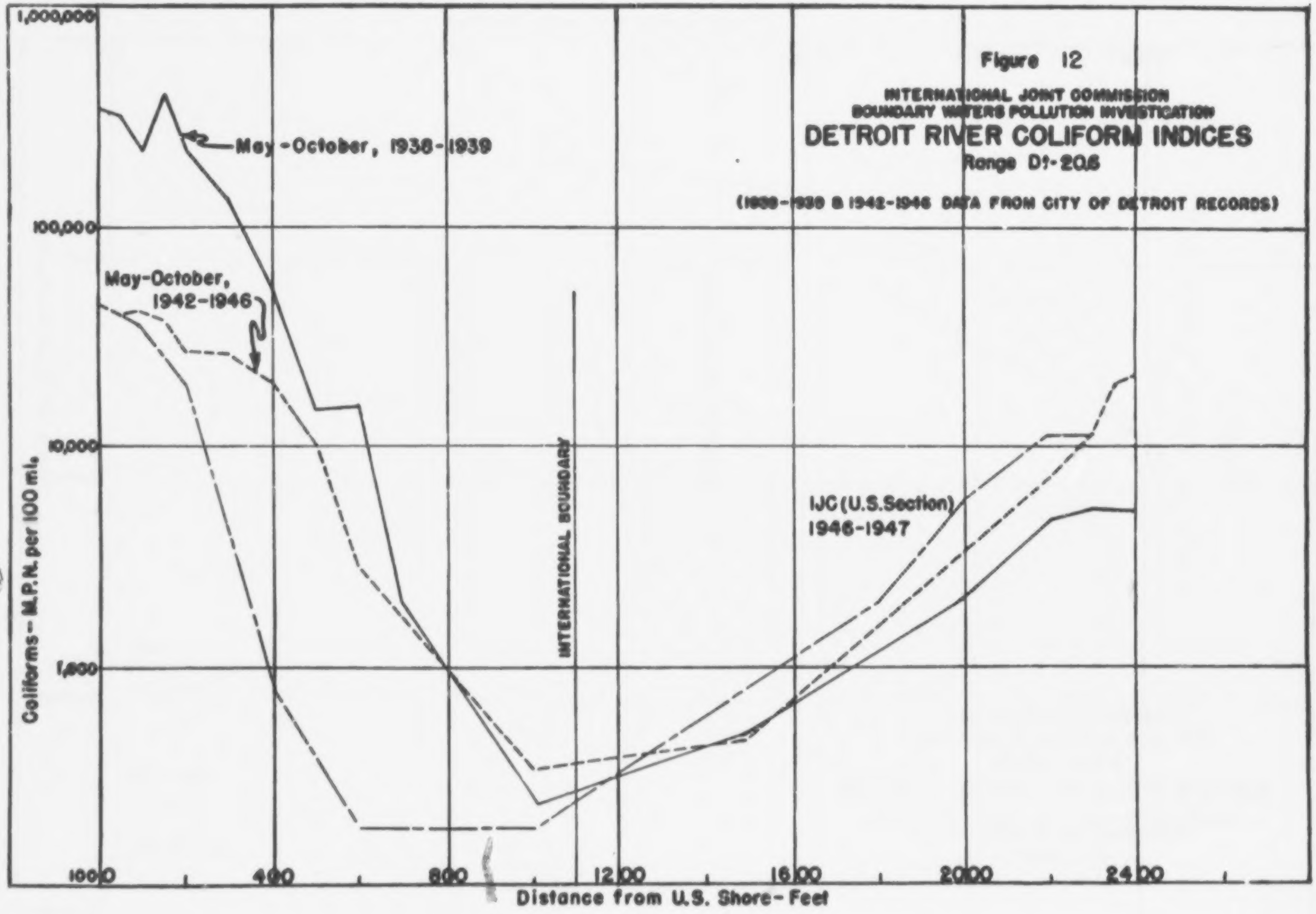

Figure 12

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
DETROIT RIVER COLIFORM INDICES
Range D1-20.6

(1938-1939 & 1942-1946 DATA FROM CITY OF DETROIT RECORDS)

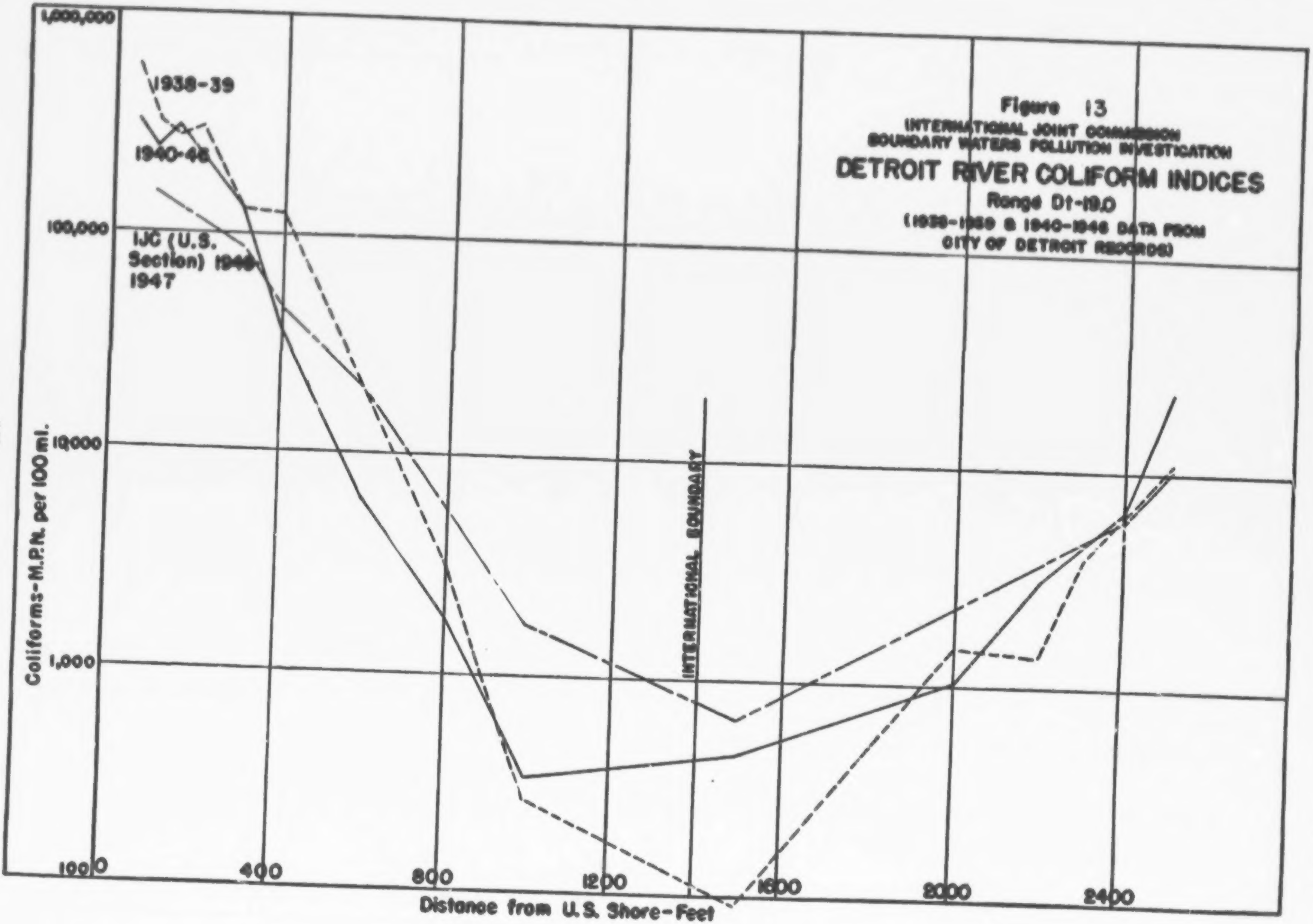

Figure 13
INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
DETROIT RIVER COLIFORM INDICES
Range Dt-19.0
(1938-1939 & 1940-1946 DATA FROM
CITY OF DETROIT RECORDS)

Chapter IX

TRANSBOUNDARY MOVEMENT OF POLLUTION

In the treaty of 1909 between the two countries it was agreed that "the boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other." In the reference for this investigation an answer was sought to the questions of whether transboundary movement of pollution was taking place, to what extent, and in what localities. The information utilized in answering these questions was obtained from float studies, special investigations, and a review of data from various sources.

Float Movements

It is apparent from information presented in chapter IV that transboundary currents occur at various places in this section. In the St. Clair River, surface float studies indicated a crossing of surface waters from the Canadian side to the United States side in the area between St. Clair and Marine City. Similar floats released on the United States side were generally carried downstream and crossed to the Canadian side between Courtright and Sombra. Reports were received on 380 out of a total of 1,020 surface floats released in the St. Clair River. Of these, 32 crossed from the United States to Canada, and 97 crossed from Canada to the United States. On the other hand, a three weeks' study of sub-surface floats submerged to depths of 2 to 20 feet and released along both shores, in the Sarnia-Port Huron area, revealed that they followed a course parallel to the shores and showed no pronounced tendency to cross the International Boundary. The deeper floats, at 15 to 20 feet, released on the Canadian side near Port Lambton, travelled down the Chenal Ecarte, while those submerged to depths of less than 10 feet followed down the main or South Channel and probably across the boundary.

In Lake St. Clair both surface and depth floats crossed the boundary at different points. Movements of water were not well defined but depended largely on wind direction and intensity. Surface floats released at the outlet of Anchor Bay crossed the boundary to Mitchell Bay, and the south shore of the lake. Depth floats also followed a similar course toward the boundary. It is probable that these would cross the boundary under certain wind conditions. There was no indication of currents from the east side of Lake St. Clair crossing the boundary prior to the approach to the Detroit River.

In the Detroit River, surface floats crossed from side to side throughout the length of the stream. In the upper part these floats crossed from the United States side through the opening between Peach Island and Belle Isle to the Canadian side. Several surface floats released at the mouth of the Rouge River and in the vicinity of the Detroit sewage treatment plant outlet were found on the Canadian shore opposite the upper end of Fighting Island. Only those depth floats placed 1,000 feet or more off the United States shore, opposite Windmill Point, crossed the boundary. A limited number of depth floats placed in United States waters near the boundary at the head of Fighting Island crossed into Canadian waters at the foot of this island.

Belle Isle-Peach Island Studies

Hydrometric data showed a division of flow which transfers 40 percent of the total river volume from the United States side through the opening between Belle Isle and Peach Island to the Canadian side of Belle Isle. The boundary cross-over at this location prompted a special study in the spring of 1948 to determine the existence of any transfer of pollution with this flow.

A system of ranges and sampling points was established across the several channels between the United States and Canadian shores in that section of the Detroit River between Peach Island and Belle Isle. The locations of these ranges and sampling points are indicated in figures 14 and 15. These also show the distribution of average analytical results.

Numerous samples of the river water were collected for examination of the more significant indices of pollution including coliforms, turbidity, chlorides and ammonia. A summary of the analytical results, showing the coliform figures, is presented in table 26 (see page 164).

The coliform indices for the various ranges used in this study tend to confirm the observations on float behavior. Accordingly, under normal conditions, a transfer may be expected to occur only when the pollution from the United States side extends beyond 1,000 feet from shore in the vicinity of Windmill Point. Abnormal conditions of storm discharge and wind action may extend this zone of shore pollution beyond the usual limit in the river. There is indication of this in the maximum M.P.N. values at ranges Dt-30.0 and Dt-30.8w. While the median figures steadily decrease from

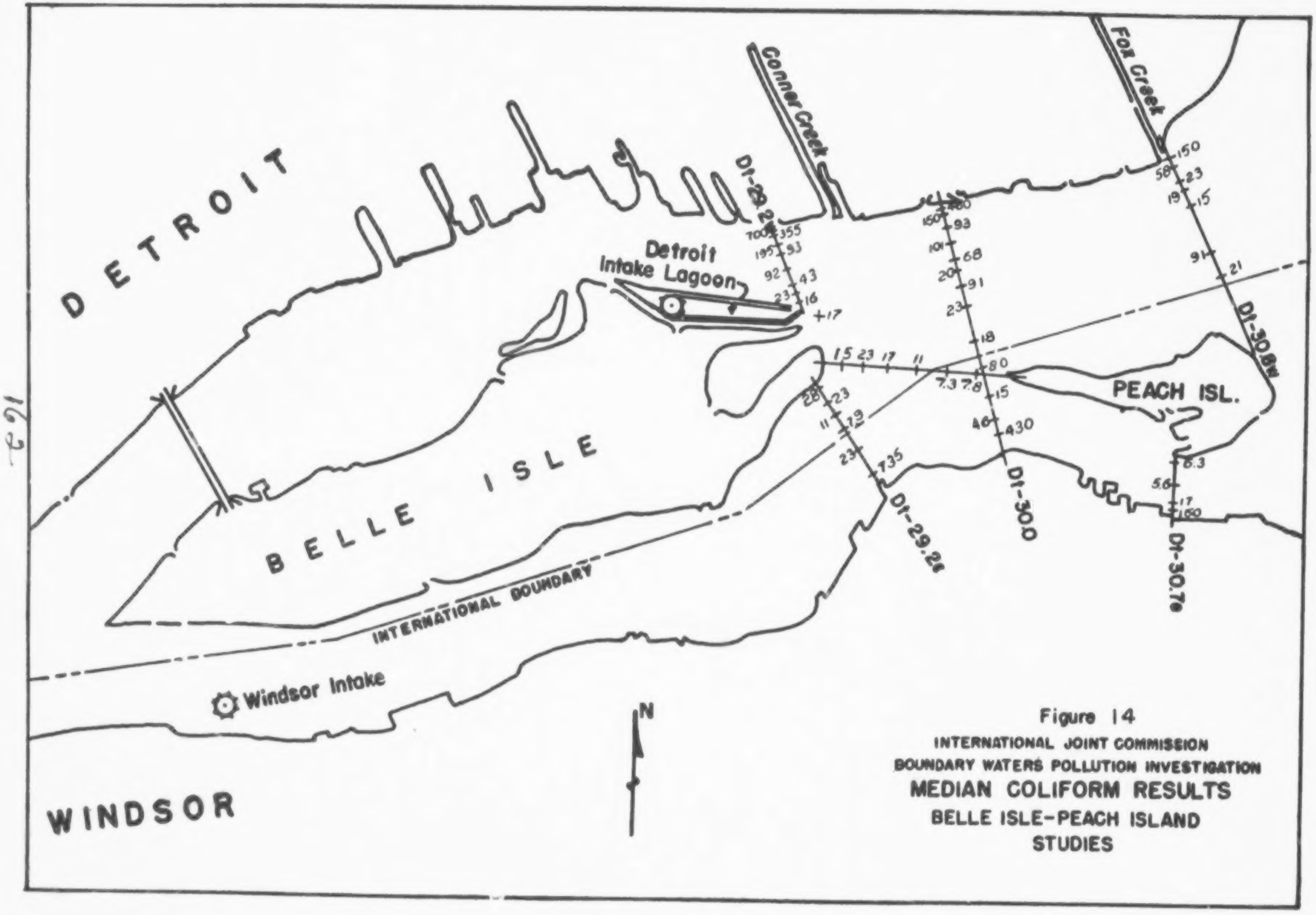
DETROIT
WINDSOR
BELLE ISLE
PEACH ISL.
Detroit Intake Lagoon
Conner Creek
Fox Creek
Windsor Intake
INTERNATIONAL BOUNDARY
N
Dt-29.2W
700
355
195
93
92
43
23
16
+17
Dt-29.2E
28
23
11
7.9
23
7.35
1.5
23
17
11
7.3
7.8
Dt-30.0
2400
150
93
101
68
20
91
23
18
80
15
46
430
Dt-30.8W
150
58
23
19
15
91
21
Dt-30.7E
6.3
5.6
17
1100

Figure 14

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
MEDIAN COLIFORM RESULTS
BELLE ISLE-PEACH ISLAND
STUDIES

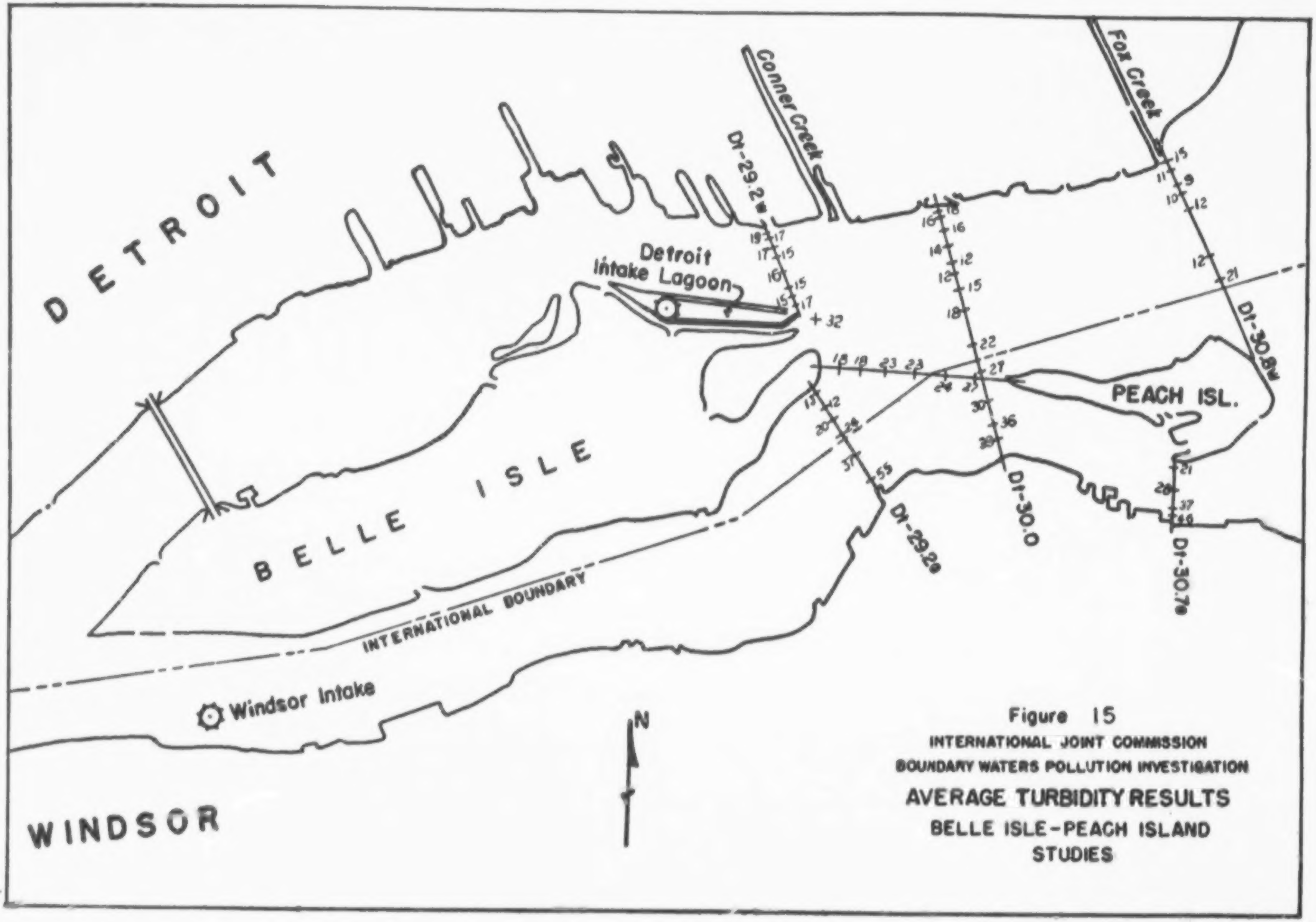
DETROIT
Conner Creek
Fox Creek
Detroit
Intake Lagoon
Dt-29.2w
19 17
17 15
16 15
15 17
+ 32
16 18
16
14 12
12 15
18
22
27
Dt-30.0
15
11 9
10 12
12 21
Dt-30.8w
18 18 23 23
24 27
30
36
39
PEACH ISL.
13 12
20 28
37
55
Dt-29.2e
21
28
37
46
Dt-30.7e
BELLE ISLE
INTERNATIONAL BOUNDARY
Windsor Intake
N
WINDSOR

Figure 15

INTERNATIONAL JOINT COMMISSION

BOUNDARY WATERS POLLUTION INVESTIGATION

AVERAGE TURBIDITY RESULTS

BELLE ISLE-PEACH ISLAND

STUDIES

shore toward midstream the maximum figures indicate an extended zone of pollution at certain times.

Turbidity results shown in figure 15, on these two ranges, indicate a distribution comparable to that of the coliforms.

TABLE 26—COLIFORM RESULTS—BELLE ISLE-PEACH ISLAND STUDIES

Mileage Index Number	Distance from Shore (Feet)	Number of Samples	Coliforms—M.P.N. per 100 ml.		
			Median	Maximum	Minimum
Dt-30.8w	20	9	150	24,000	1.8
	200	9	58	1,100	1.8
	500	9	23	2,400	1.8
	700	9	19	1,100	1.8
	1000	9	15	3,500	1.8
	2000	9	9.1	1,700	1.8
	2500	9	21	43	1.8
	2600	INTERNATIONAL BOUNDRY			
Dt-30.7e	100	9	6.3	43	1.8
	500	9	5.6	23	3.0
	850	9	17	460	1.8
	980	9	150	5,400	17
Dt-30.0	100	13	460	17,000	13
	200	13	150	4,600	2.0
	400	13	93	2,600	4.0
	700	13	101	350	1.8
	1100	13	68	240	1.8
	1300	13	20	920	1.8
	1600	13	9.1	1,600	4.5
	2000	13	23	93	3.6
	2700	13	18	350	1.8
	3300	13	8.0	2,400	2.0
	3900	13	15	93	1.8
	4300	13	46	1,500	1.8
	4600	13	430	3,100	46
Dt-29.7	3000	14	7.8	220	1.8
Dt-29.6	3000	14	7.3	23	1.8
Dt-29.5	3000	13	11	43	1.8
Dt-29.4	3000	14	17	79	2.0
Dt-29.34	3000	14	23	460	1.8
Dt-29.26	3000	15	15	540	1.8
	1700	7	17	240	2.0
Dt.29.2e	100	12	28	430	1.8
	400	12	23	220	2.0
	700	12	11	43	1.8
	1000	11	7.9	93	1.8
	1500	12	23	540	3.6
	2000	12	735	35,000	33
Dt-29.2w	100	12	700	160,000	11
	250	12	355	8,400	4.5
	400	12	195	2,400	4.5
	600	12	93	5,400	1.8
	900	12	92	540	1.8
	1300	12	43	240	4.0
	1500	12	23	930	1.8
	1700	12	16	430	2.0

Supplementary Information

Certain information in addition to that already discussed has been utilized in determining the transboundary movement of pollution.

Indications of coliform pollution crossing the boundary are seen at a number of places. In the St. Clair River there is a diffusion of coliforms at range SR-17.5, between Sombra and Marine City, after passage through a narrow section of the river. This indicates a transboundary movement of pollution. In Lake St. Clair the coliform concentrations indicate a flow of pollution from Anchor Bay across the boundary similar to the path followed by the floats. Diffusion of coliform concentrations occur at several places in the lower Detroit River, beginning on the Canadian side at the head of Fighting Island. This may be influenced by material from across the boundary. More uniform distribution is found at range Dt-12.0w in Trenton Channel and at range Dt-9.3e, which crosses the boundary above Amherstburg. These ranges are on either side of Grosse Ile. On range Dt-3.9, at the mouth of the Detroit River, there is a trend to uniform distribution across the entire width of the river.

Transboundary movement of pollution was demonstrated by an accidental spill of phenol in the Sarnia area. This took place on November 30 and December 1, 1948. Severe taste occurrences were reported at Wallaceburg on December 1, and at the Detroit water treatment plant on December 7 to 10. This was followed by tastes at Windsor on December 14 and 21. At neither Detroit nor Windsor did these tastes reach the consumers.

Similarly on February 15, 1946, Wallaceburg had a severe phenolic taste in the municipal water supply. On February 20 distinct taste occurrences were common to both Detroit and Windsor, further indicating a probable transboundary movement.

Oils and greases were observed on both sides of the boundary at various places. In view of the paths of surface floats it is obvious that these substances do cross the boundary.

Reference has been made to reversals of flow in the Detroit River and Lake St. Clair. As a result of the mixing which occurs in the lower Detroit River it is probable that there will be a transboundary flow of pollution under these conditions.

In addition to transboundary carriage of pollution by natural agencies transfer is brought about by artificial means such as navigation, dredging, and industries. Vessels take on and discharge ballast water at both sides of the boundary. Dredging operations may carry pollution across the boundary as the result of depositing masses of heavy pollution near the boundary line. One industry in the United States pipes its wastes to waste beds on Fighting Island, and these beds overflow into Canadian waters.

The several data presented herewith clearly demonstrate the transfer of pollution from either side of the boundary to the other at a number of locations.

Chapter X

DISCUSSION OF FINDINGS AND REMEDIAL MEASURES

Data presented in this report show the results of the investigation of pollution in the Lake Huron-Lake Erie section of the boundary waters. They indicate, in accordance with the terms of reference to the Commission, the extent, nature and sources of pollution, and in what localities such pollution occurs. The Board has examined and evaluated these various data. From this analysis certain conclusions have been reached and remedial measures have been determined. The findings and conclusions are discussed herewith.

Canada and the United States jointly possess an unparalleled natural resource in these boundary waters. They constitute the largest body of fresh water in the world and are subject to a multiplicity of uses. Because they vitally affect the health, economy and recreation of both countries it is essential that the waters be so safeguarded from pollution that their use will be in the highest public interests. The importance attached to the requirement of maintaining these waters in an unpolluted state is evident in the action taken by the two governments, on two separate occasions, in requesting that the International Joint Commission make an investigation of pollution.

The 1913 Investigation

The pollution problem in 1913 was materially different from that of today. The earlier investigation was concerned solely with bacterial pollution from domestic sewage. The industrial processes, then in use, did not discharge waste products in sufficient quantities to affect seriously the condition of the waters. It was pointed out, however, that the industrial wastes might soon create a problem and require regulation.

It has been stated in chapter VIII that certain areas of the boundary waters were seriously polluted in 1913, with the worst conditions being found in the Detroit River and St. Clair River, below major centers of population. There were no municipal sewage treatment plants then in operation, and the sewage was discharged through many outlets along the waterfront. All municipalities obtained their drinking water supplies from the adjacent waters above their own sewer outfalls. The only safeguard against contamination was chlorination of the water. Filtration was not in use on any municipal supply.

The International Joint Commission, following the 1913 investigation, recommended to the two governments that, for the boundary waters as a whole,

> "It is feasible and practicable, without imposing an unreasonable burden upon the offending communities, to prevent or remedy pollution, both in the case of boundary waters and waters crossing the boundary.
>
> "(a) In the case of city sewage, this can best be accomplished by the installation of suitable collecting and treatment works, the latter having special reference to the removal of bacteria and matters in suspension.
>
> "(b) In the case of vessel sewage, a feasible and inexpensive remedy lies in the employment of recognized methods of disinfection before it is discharged. In the case of water ballast suitable rules and regulations should be prescribed with a view of protecting the water intakes.
>
> "(c) The discharge of garbage and sawmill waste into boundary waters should be prohibited, and industrial and other wastes, which are causing appreciable injury, should be discharged subject to such restrictions as may be prescribed."

Changes in Period 1913-1946

Many changes have taken place in the period from 1913 to 1946 which have affected the pollution problem. Two factors which have contributed adversely to this problem are the increases in population and industrial activities. Comparative populations in the Lake Huron-Lake Erie section in 1913 and 1948 are shown in table 27. The population has risen from 772,100 to 2,589,600. It should be noted that these figures cover only those municipalities situated on the boundary waters. The populations residing on the waters tributary to the boundary streams and lakes are not included.

Although the matter of industrial wastes was of little or no concern in 1913 it is today a major problem. Vast expansion in industrial activities has resulted in great volumes and varieties of wastes.

The pollution problem in the interval from 1913 to 1946 has forced municipalities to construct sanitary works for water supply protection. Virtually all municipalities, with the exception of Port Huron and Sarnia, both above the sources of pollution, have installed water filtration plants. Installations for the treatment of domestic wastes have not kept pace with the extension of sewer services and the

TABLE 27—POPULATIONS SITUATED ON BOUNDARY WATERS, 1913 AND 1948

Area	1913			1948		
	Canada	United States	Total	Canada	United States	Total
St. Clair River	9,900	29,100	39,000	31,400	52,000	83,400
Lake St. Clair	15,800	12,300	28,100	30,900	74,900	105,800
Detroit River	26,000	679,000	705,000	142,300	2,258,100	2,400,400
Total	51,700	720,400	772,100	204,600	2,385,000	2,589,600

treatment of water supplies, but definite progress has been made. The city of Detroit has installed interceptors and sewage treatment works to provide primary treatment for the city and over 20 surrounding communities. Other treatment plants were built at Dearborn, Wyandotte, and Trenton in Michigan, and at Riverside in Ontario. These plants now give primary treatment for 2,250,000 persons on the United States side and secondary treatment for 5,000 persons on the Canadian side. Much of the cost of this work on the United States side was financed with Federal Government aid during the period of 1933 to 1940.

In this same period, sanitary science has made important contributions toward solving pollution problems. Research in analytical procedures and treatment methods has made it possible to define more clearly, both qualitatively and quantitatively, the nature, extent, and effects of pollution and to apply corrective measures.

The science of water purification in 1913 was in the initial stages of development. While filtration had been developed it had not been employed anywhere along these boundary waters. Chlorine was added to the water in the form of hypochlorite, but the method of application was crude and often ineffective. Present day methods in chlorine application and control for disinfection were unknown. Most cities and towns with the highest typhoid fever rates used water without the safeguard of either effective filtration or chlorination.

Corresponding advances have been made in the art of sewage and industrial waste treatment. New and improved processes have resulted in greatly increased efficiencies and in the removal, to a high degree, of objectionable polluting substances.

Extent and Effects of Pollution in 1946-1948

The 1946-1948 investigation revealed pollution in numerous localities, originating from many sources. The analytical data, derived from bacteriological, chemical, and physical examinations, are a measure of the extent and effects of various pollutants on waters used for the purposes already enumerated. The kinds, degree, and locations of pollution are set forth in detail in chapters VII and VIII. The findings are reviewed herewith in the light of their effects on these waters and in relation to the questions contained in the terms of reference.

Transboundary Movement

In the treaty of 1909 between the two countries it was agreed that the waters on either side of the boundary should not be polluted to the injury of health or property on the other side. The first question asked in the present reference to the Commission involves this transboundary aspect of the pollution problem.

The data presented in chapter IX have shown clearly that there is a transboundary crossing, both of currents and pollution, from each side to the other. Since waste discharges tend to diffuse and become diluted with the receiving waters, it is difficult to trace a specific effluent over the distance required to dissipate its potency. Added dilution through travel downstream and the admixture of similar or other deleterious materials further complicate this difficulty. The intermingling is also influenced by winds, bends in the river, islands or other obstructions, and navigation channels. These effects may not be constant. Under these circumstances it is not feasible to state, in exact terms, the amount of pollution which crosses from each country to the other.

Injury to Health

The danger to health in the use of these waters is measured most readily by the coliform determinations, although constitutents of a chemical nature are also of sufficient importance to warrant consideration. Major purposes for which these waters are used include domestic water supply, bathing, and recreation. All of these uses are closely allied to public health and are injuriously affected by the discharge of bacterial and chemical wastes.

Limits of pollution beyond which a health menace may exist are not universally accepted. Several standards have been formulated from time to time to apply to specific areas and requirements. In the final report on the 1913 investigation the Commission stated that "the standard of purification required of these communities should be such that the streams after receiving their treated sewage would have a mean annual cross-sectional average of B. coli not exceeding 500 per 100 c.c." A more recent standard for raw waters, acceptable for treatment and use as public water supplies, is that recommended by the U. S. Public Health Service in 1946. In this recommendation, waters which have an average monthly coliform content of not more than 50 per 100 ml. are acceptable for treatment by simple chlorination alone. Raw waters having an average monthly coliform content of not more than 5,000 per 100 ml. and exceeding this number in not more than 20 percent of the samples examined in any one month are acceptable for treatment by complete rapid sand filtration and continuous postchlorination. In cases where the coliform bacteria exceed 5,000 per 100 ml. in more than 20 percent of the samples examined during any one month and do not exceed 20,000 per 100 ml. in more than 5 percent of the samples examined during any one month the waters shall be acceptable when given auxiliary treatment in addition to complete rapid sand filtration and continuous postchlorination. Waters containing coliform bacteria in excess of the above figures are considered unsuitable for use as a source of drinking water supply unless brought into conformance by means of prolonged preliminary storage or some other satisfactory measure.

Since practically all of the municipalities on the Lake Huron-Lake Erie section obtain their supplies from the boundary waters, pollution by human sewage may be said to affect the entire population. While there have been no typhoid fever outbreaks attributable to public water supplies in either Michigan or Ontario in recent years, the effects of water pollution have been manifested in other ways. Advances in water purification in the last 30 years have done much to reduce the menace of waterborne typhoid fever, but sewage contaminated waters can result in outbreaks of gastro-enteritis, particularly the diarrheas and dysenteries. Evidence of this is found in the occurrence at Detroit in 1926, when 45,000 persons were affected. The incident was reported to have been traced to the municipal water supply even though it was filtered and chlorinated. Other similar occurrences have been reported.

All sewage pollution must be considered as a potential health hazard. Pollution also adds an extra burden in the form of higher costs for water purification, necessitated by the failure of some upstream user to treat adequately the wastes produced. Similarly, many riparian owners who may wish to use these waters are not in position to secure the protection provided by modern and properly controlled purification processes that can be installed by municipal bodies. Some municipalities are deprived of the right of developing public water supplies within economical limits. One example of this is seen in the necessity for abandoning the water supply at Trenton, Michigan, and for extending the intake at Wyandotte, Michigan, at a cost of $185,000.

It was shown in chapter VIII that the coliform pollution in the St. Clair River rises sharply below the cities of Port Huron and Sarnia and is sustained throughout the length of the river. The pollution is generally greatest near the shores. In a number of places the coliform figures are in excess of those considered safe for a raw water to be treated even by modern purification methods. The maximum counts reach excessive values, and thereby would impose a severe load on water purification processes. While it is still possible to locate intakes in zones where the bacterial pollution is within the limits recommended by the U. S. Public Health Service as acceptable, the water requires careful and sustained treatment to render it safe for drinking purposes.

In Lake St. Clair, the coliform values vary widely. Normally, in the central portion of the lake these figures are within the limits recommended for a public water supply protected by simple chlorination. In the vicinity of sewage outfalls and at the mouths of tributary streams the coliform index reaches high values and is in excess of the figure for safe water even when protected with modern purification processes. The worst condition is found on the United States side of the boundary. Natural purification agencies play an important role in reducing the pollution load discharged into the lake to a concentration where, in general, the water can be safely treated for domestic use.

The Detroit River contains the highest concentrations of coliform organisms found in the Lake Huron-Lake Erie section. The water treatment plants of Detroit and Windsor enjoy the benefit of natural purification effected in Lake St. Clair. Proceeding downstream the coliform pollution progressively increases. In the lower river, which is the source of water supplies for Wyandotte and Amherstburg, the coliform index far exceeds the limits for waters acceptable for treatment under the U. S. Public Health Service recommendations. These values are discussed in chapter VIII. In this area are found the difficulties and dangers associated with a highly polluted water as a public supply.

Tastes and odors in water supplies are caused principally by industrial wastes, and particularly phenolic compounds. One-tenth of one part per million of phenol alone will impart to water the characteristic taste and odor of carbolic acid. In water supplies which are chlorinated to protect against bacterial pollution, phenols react with chlorine to produce intensely aromatic compounds.

These compounds, even when highly diluted, give to the water tastes and odors which are variously described as medicinal, chemical or iodoform. Two one-thousandths of one part of phenol in one million parts of chlorinated water (2 p.p.b.) may be sufficient to cause objectionable tastes and odors. This condition often compels the public to resort to other water supplies, which may be palatable but dangerously contaminated. The figures given in chapter VIII show phenolic concentrations in many places sufficiently high to cause objectionable tastes and odors. This taste situation is greatly aggravated by the wide variation in the phenol content of the industrial wastes, as well as by winds, currents, and other hydrometric conditions.

The ammonium ion of ammonium compounds in water supplies tends to combine with chlorine to form chloramines. Varying amounts of this substance present in water cause fluctuations in the chlorine demand. Erratic chlorine demand is a public health hazard, because it interferes with the disinfection of water supplies.

The presence of sewage pollution in the bathing areas located in these waters also constitutes a health hazard. The coliform data in chapter VIII show that the shore waters are heavily contaminated in a large part of the Lake Huron-Lake Erie section, and in excess of an M.P.N. value of 2,400 per 100 ml. This has resulted in inconvenience and extra cost to the local population for travelling to more distant points. There are few areas in this section of the boundary waters available for public bathing, and it has been necessary to close most of these at times for health reasons.

The city of Detroit has, by ordinance, prohibited bathing along its entire water front. There is the further problem of those who do not have access to safe bathing facilities and who disregard the danger from swimming in heavily polluted areas.

Injury to Property

Property has been injured through the discharge of sewage and industrial wastes into these waters. Bacterial pollution has added to the cost of water treatment. It has also meant an economic loss for owners of bathing beaches and for the owners of properties which could be developed for this purpose. The discharge of industrial wastes has interfered with the use of these waters and has resulted in property damage. Wastes containing oils, greases or tars have fouled bathing beaches, coated swimmers, and caused destruction of wildfowl. Any concentration of oil coats the hulls of boats and docks and creates a fire hazard.

Phenols from industrial wastes interfere with the enjoyment of property rights by increasing the cost of water treatment or by excluding the use of the water for industrial or domestic purposes. Phenol in water kills fish by producing paralysis of the neuromuscular mechanism and hemolizing the blood. Fish tend to swim toward higher concentrations of phenol. Cases have been reported where the concentrations of phenol were not large enough to destroy the fish, but the flesh was tainted with phenol and was inedible.

Ammonium compounds increase the cost of water treatment and are toxic to fish. Cyanides, strong acids, and oxygen-depleting wastes have caused the destruction of fish and wild life. Aesthetic values have been injured by promiscuous discharge of such materials as refuse, oils, greases, and tars. All of these conditions are found in these watercourses.

Sources of Pollution

Pollution of these waters is due principally to the discharge of domestic sewage and industrial wastes. Many industries dispose of their wastes into public sewers, others have separate outlets directly to the boundary waters or their tributaries. While wastes are discharged throughout the entire section of these waters, there are several zones in which the volume of pollution is concentrated.

Sources of Domestic Wastes

Table 12, in chapter VII, lists the principal sources of domestic wastes. The outfalls for these wastes are grouped at the centers of large populations.

On the United States side of the St. Clair River the major portion of the domestic wastes is contributed by Port Huron and the surrounding areas. The sewered population of over 31,000 at Port Huron alone constitutes 75 percent of the total sewered population on this side of the river. Raw sewage from municipalities downstream from Port Huron tends to sustain the pollution load in the river and offset the effects of dilution and natural purification. On the Canadian side the entire sewered population of 23,000 is in the Sarnia area. At present, no community downstream from this area has public sewers, but it may be anticipated that sewers will be provided later.

In Lake St. Clair the major discharge of domestic wastes, on the United States side, occurs along the west shore, chiefly from the Clinton River. There are intermittent discharges at points south of the Clinton River caused by combined sewer overflows. The dry weather sewage flow from the communities responsible for these overflows is normally pumped to the Detroit sewer system. For periods of five months or more each year the entire flow of sewage from the South Macomb Sanitary District is discharged untreated directly to the lake. The sewered population on the Canadian side is confined chiefly to tributary streams. The outfalls are not concentrated at any point on the boundary waters.

In the Detroit River, on the United States side, the discharge of domestic wastes is concentrated in the lower reaches extending from the Rouge River to Lake Erie. The principal sources of pollution are the Rouge River, Detroit sewage plant effluent, and sewage from the communities along the Trenton Channel. The lower Rouge River receives domestic sewage from a population of 326,000, nearly all of which is given partial treatment. The Detroit plant, providing primary treatment of the sewage, serves a sewered population of 2,200,000. Not all of the city's sewage reaches the plant. Some raw sewage enters the river at a number of outlets along the waterfront. The Trenton Channel outfalls, from plants giving primary treatment, serve a sewered population in excess of 100,000. On the Canadian side, in the Windsor area, raw sewage is discharged through multiple outlets from a population of nearly 120,000. Downstream, the Amherstburg area adds raw sewage from a sewered population of about 2,000.

In the Lake Huron-Lake Erie section, the present survey showed a daily discharge of 514 million U. S. (428 million Imp.) gallons of municipal wastes. Of this amount, about 400 million U. S. (333 million Imp.) gallons receive some degree of treatment. This proportion of treatment does not apply at all times since these communities have provision for spilling combined storm and sanitary flows directly into the streams during periods of high runoff.

Sources of Industrial Wastes

A summary of industrial waste discharges, showing distribution by areas, is given in table 16 of chapter VII. These wastes are discharged throughout the Lake Huron-Lake Erie section, but heavy concentrations occur in certain zones. A total of 1,430 million U. S. (1,191 million Imp.) gallons is discharged daily. This volume includes condenser and cooling water as well as process wastes. These effluents contain large quantities of pollutants which have an adverse effect on the receiving waters. The daily discharge of the more significant of these wastes was found to be: 6,340 pounds of phenols, 3,700 pounds of cyanides, 11,600 pounds of ammonium compounds, 18,730 U. S. (15,590 Imp.) gallons of oils, 2,296,000 pounds of suspended solids, and organic matter having a biochemical oxygen demand of 354,500 pounds. These last two quantities do not include the entire population load from the seasonal operation of certain food processing industries. Most of such industries are on tributary streams.

Sources of Other Wastes

In addition to municipal and industrial effluents, these waters receive wastes from navigation, dredging, and careless dumping of refuse at shore points.

In 1947, at the height of the navigation season, the domestic sewage discharge from vessels was equivalent to that from a daily population of 3,900 and amounted to an estimated 120,000 U. S. (100-000 Imp.) gallons per day. For this same period, the estimated amount of garbage averaged 2,000 pounds per day. Bilge water contained an estimated quantity of 40 (U. S.) gallons of oil per day. No estimate was possible for the amount of ballast water, or the amount of polluting substances transferred from place to place in this water.

The character of the wastes resulting from dredging operations is dependent upon the source of the dredged material. Substantial amounts of polluting substances can be transferred in this way. Reference has been made in chapter VII to the amount of pollutants removed from the Rouge River and dumped into the Detroit River.

There is no widespread dumping of garbage or other refuse into these waters, but some does occur from small water craft, shore residences, and by careless persons. This practice causes unsightly appearances in some local areas.

Remedial Measures

It has been shown that serious pollution exists in the Lake Huron-Lake Erie section of the boundary waters. Its nature, extent, and sources have been presented in detail. This pollution has an injurious effect on the uses of these waters for domestic and industrial water supplies, bathing, recreation, and fish and wild life. It crosses from each side of the boundary to the other. A further question in the terms of reference concerns the measures necessary for remedying the situation. If such measures are to be effective, they must raise the quality of the waters to the point where they can be used satisfactorily for these various purposes.

Objectives for Boundary Waters Quality Control

Remedial measures involve the treatment or control of all sources of pollution reaching the boundary waters and their tributaries. Information acquired during the investigation enabled the Advisory Board to prepare "Objectives for Boundary Waters Quality Control."

The formulation of water quality objectives is essential for defining the remedial measures necessary for correcting pollution. Objectives may be established in two ways: (1) through limitation of the quantity of deleterious substances allowed to enter the receiving streams, or (2) through limitation of these substances within the receiving waters. Whichever type of objective is used, the end result must be the same, namely, maintenance of the water in a condition suitable for all subsequent uses.

Objectives adopted for boundary waters quality control establish the ultimate aim of corrective measures. Objectives must be defined if stream sanitation is to be accomplished, and they must be impartial in setting goals for all uses. Each purpose will require a specific quality of water. In the majority of cases, the uses of any one watercourse are varied, and complex interrelationships must be considered in objectives consistent with all uses. These principles have been adhered to in the formulation of the following objectives, and as revised October, 1949.

The term "boundary waters" as herein used shall include the waters defined in the references to the International Joint Commission dated April 1, 1946, and October 2, 1946, as follows:

St. Clair River, Lake St. Clair, the Detroit River, and St. Marys River from Lake Superior to Lake Huron.

These objectives are for the boundary waters in general, and it is anticipated that in certain specific instances, influenced by local conditions, more stringent requirements may be found necessary.

General Objectives

All wastes, including sanitary sewage, storm water, and industrial effluents, shall be in such condition when discharged into any stream that they will not create conditions in the boundary waters which will adversely affect the use of these waters for the following purposes: source of domestic water supply or industrial water supply, navigation, fish and wild life, bathing, recreation, agriculture and other riparian activities.

In general, adverse conditions are caused by:

(A) Excessive bacterial, physical or chemical contamination.

(B) Unnatural deposits in the stream, interfering with navigation, fish and wild life, bathing, recreation, or destruction of aesthetic values.

(C) Toxic substances and materials imparting objectionable tastes and odors to waters used for domestic or industrial purposes.

(D) Floating materials, including oils, grease, garbage, sewage solids, or other refuse.

Specific Objectives

In more specific terms, adequate controls of pollution will necessitate the following objectives for:

(A) *Sanitary Sewage, Storm Water, and Wastes from Water Craft*

Sufficient treatment for adequate removal or reduction of solids, bacteria and chemical constituents which may interfere unreasonably with the use of these waters for the purposes afore-mentioned.

Adequate protection for these waters, except in certain specific instances influenced by local conditions, should be provided if the coliform M. P. N. median value does not exceed 2,400 per 100 ml. at any point in the waters following initial dilution.

(B) *Industrial Wastes*

(1) Chemical Wastes — Phenolic Type

Industrial waste effluents from phenolic hydrocarbon and other chemical plants will cause objectionable tastes or odors in drinking or industrial water supplies and may taint the flesh of fish.

Adequate protection should be provided for these waters if the concentration of phenol or phenolic equivalents does not exceed an average of 2 p.p.b. and a maximum of 5 p.p.b. at any point in these waters following initial dilution. This quality in the receiving waters will probably be attained if plant effluents are limited to 20 p.p.b. of phenol or phenolic equivalents.

Some of the industries producing phenolic wastes are: coke, synthetic resin, oil refining, petroleum cracking, tar, road oil, creosoting, wood distillation, and dye manufacturing plants.

(2) Chemical Wastes, Other Than Phenolic

Adequate protection should be provided if:

(a) The pH of these waters following initial dilution is not less than 6.7 nor more than 8.5. This quality in the receiving waters will probably be attained if plant effluents are adjusted to a pH value within the range of 5.5 and 10.6.

(b) The iron content of these waters following initial dilution does not exceed 0.3 p.p.m. This quality in the receiving waters will probably be attained if plant effluents are limited to 17 p.p.m. of iron in terms of Fe.

(c) The odor-producing substances in the effluent are reduced to a point that following initial dilution with these waters the mixture does not have a threshold odor number in excess of 8 due to such added material.

(d) Unnatural color and turbidity of the wastes are reduced to a point that these waters will not be offensive in appearance or otherwise unattractive for the aforementioned uses.

(e) Oil and floating solids are reduced to a point such that they will not create fire hazards, coat hulls of water craft, injure fish or wild life or their habitat, or will adversely affect public or private recreational development or other legitimate shore line developments or uses. Protection should be provided for these waters if plant effluents or storm water discharges from premises do not contain oils, as determined by extraction, in excess of 15 p.p.m., or a sufficient amount to create more than a faint iridescence.

Some of the industries producing chemical wastes other than phenolic are: oil wells and petroleum refineries, gasoline filling stations and bulk stations, styrene co-polymer, synthetic pharmaceutical, synthetic fibre, iron and steel, alkali chemical, rubber fabricating, dye manufacturing, and acid manufacturing plants.

(3) Highly Toxic Wastes

Adequate protection should be provided for these waters if substances highly toxic to human fish, aquatic, or wild life are eliminated or reduced to safe limits.

Some of the industries producing highly toxic wastes are: metal plating and finishing plants discharging cyanides, chromium or other toxic wastes; chemical and pharmaceutical plants and coke ovens. Wastes containing toxic concentrations of free halogens are included in this category.

(4) Deoxygenating Wastes

Adequate protection of these waters should result if sufficient treatment is provided for the substantial removal of solids, bacteria, chemical constituents and other substances capable of reducing the dissolved oxygen content of these waters unreasonably. Some of the industries producing these wastes are: tanneries, glue and gelatin plants, alcohol, including breweries and distilleries, wool scouring, pulp and paper, food processing plants such as meat packing and dairy plants, corn products, beet sugar, fish processing and dehydration plants.

Note: The methods of determination of the chemical constituents referred to in the preceding objectives are as given in "Analytical Methods for Boundary Waters Quality Control," as prepared by the Board of Technical Advisers. Bacterial determinations are to include the presumptive and confirmed tests for the coliform group of bacteria as given in "Standard Methods for the Examination of Water and Sewage," 9th Edition.

Hearings Before the Commission

Public hearings for municipalities, industries, and all other interested parties were held by the Commission at Detroit and Windsor at the conclusion of the field studies. The purpose of these hearings was to obtain information on waste treatment processes now in use or proposed, cost estimates of remedial measures, time required to carry out these measures, and comments on the application of the objectives to specific wastes. The principal points developed at the hearings were as follows:

(a) The pollution of boundary waters between the United States and Canada reached such a degree of contamination in 1945 as to stimulate complaints coming from both sides of the boundary.

(b) The evidence brought out at the hearings indicates that the pollution affecting municipal water supplies is due both to industrial wastes and domestic sewage.

(c) Pollution in boundary waters has resulted in the serious destruction of wild fowl, fish and other aquatic life.

(d) Plans of industries for dealing with their waste problems indicate that most of the industries take their responsibilities for keeping deleterious wastes out of boundary waters seriously, and are making plans or have completed works for treatment of their wastes.

(e) Plans for collecting and treating municipal wastes as well as extending existing facilities are in preparation by various municipalities, including Detroit and the metropolitan area.

(f) Municipalities are relatively inactive at the present time as far as the construction of works for treating their wastes is concerned. Boundary waters are denied the benefits of municipal pollution control by the limited ability of communities to finance treatment works.

(g) The need for promptly providing funds to construct necessary municipal treatment works has been shown.

(h) The people living near the boundary waters have been frequently thwarted in their efforts to make recreational use of boundary waters because of pollution.

(i) The expenditure of large sums to develop convenient public recreational areas indicates the desire on the part of the people for such areas.

(j) To protect recreational investments and to permit present and future industries to have access to reasonably clean waters for industrial purposes, it is necessary to curb the tendency toward increased pollution of boundary waters and to eliminate much of the pollution now being added to these waters.

(k) Regional planning, embracing the areas tributary to the boundary waters, has been indicated as a definite need to expedite and facilitate the control of pollution.

(l) Evidence has been presented that the International Joint Commission should maintain a continuing interest in the condition of these boundary waters, and that an effective way should be found in which to exercise such interest.

Pollution Control Program

It is apparent, from the data presented in the foregoing, that a comprehensive waste treatment program is required. Two methods for dealing with water pollution problems are commonly advocated. One viewpoint advocates the utilization of the stream for carrying away as much waste as it can tolerate without interfering too seriously with normal stream uses. The other would exclude all impurities from watercourses. Between these conflicting views is a course which the Board feels will meet the situation. This course has been followed in developing the "Objectives for Boundary Waters Quality Control." No tolerance limit, whether for the effluent or for the stream, can be expected to remain fixed. It must change with changing conditions and each change should be in the public interest.

The large volume of water flowing between the United States and Canada should be regarded as a natural resource to be shared by both countries. It should not be wantonly destroyed by pollution from municipalities, from industries, or from any other source. An intelligent policy of safeguarding these waters from gross pollution should be fostered and encouraged so that they will be used for the highest public good and not exploited by selfish interests. While the boundary waters should not be regarded as public sewers for carrying away wastes of all kinds, their reasonable utilization for the disposal of wastes may be permitted as long as normal water uses are not impaired.

The pollution problem must be considered not only on the basis of present-day conditions but also in terms of the future. Facilities for the treatment of municipal sewage must incorporate sufficient flexibility to permit of ready expansion to satisfy future demands. Industrial waste disposal programs must not only provide adequate treatment for the present, but they must ensure that new industries or new industrial processes which may be established will not jeopardize the rights of users of these waters. Industry must continue to assume, in co-operation with other agencies, the research and planning required for satisfactory and efficient disposal of industrial wastes.

Disposal of Municipal Wastes

Since municipal sewage carries the organisms of diseases transmissible to humans, the discharge of this waste creates a major problem in the boundary waters. The large volume of municipal wastes, totalling 514 million U. S. (428 million Imp.) gallons per day, discharged into these waters adds a heavy bacterial load. About 80 percent of this is receiving some treatment, but the treatment in practically all cases is primary only. In addition to the domestic sewage from a contributing population of 2,483,500 in this section, the municipal sewers carry a considerable amount of industrial wastes. The effects of these industrial wastes are added to the bacterial load reaching the waters through municipal outfalls.

Since 1913 the population of this section has risen from a figure of less than 800,000 to nearly 2,600,000. The final report of the 1913 investigation pointed out that these waters were seriously polluted by sewage. It was recommended that the sewage be treated either by fine screening or sedimentation and, when necessary, by chemical disinfection in order to secure in the receiving waters a mean annual cross-sectional average B. coli of 500 per 100 c.c.

Since 1913 a number of sewage treatment plants have been constructed. Notwithstanding the accomplishments of these works, the bacterial load was found in 1946-1948 to be approximately three times as great as in 1913. The primary treatment of municipal wastes which has been provided has neither reduced the bacterial load below the 1913 level nor has it even kept pace with the increase resulting from expansion of municipal populations and industrial activities.

It can be anticipated that the population in the metropolitan areas will continue to increase. The city authorities have estimated that the Detroit sewage treatment plant will ultimately serve a population of four millions. Similarly, growths may be expected throughout the entire section. While primary treatment of sewage has been provided in a number of plants, many municipalities discharge raw or inadequately treated sewage. It is obvious that, as a first step, effective primary treatment by sedimentation and disinfection of the effluent should be undertaken immediately.

It is the opinion of the Advisory Board that satisfactory quality in these waters, as outlined in the "Objectives for Boundary Waters Quality Control," will not be obtained until all municipal wastes are given continuous treatment more effective than is now realized in primary treatment plants attempting to treat both domestic sewage and certain industrial wastes. More efficient or secondary treatment undoubtedly will have to be provided. It is recognized that local conditions on either side of the boundary may give additional impetus to the need for this higher degree of treatment. The completion of the construction of such works will require an appreciable length of time, but steps should be taken without delay to inaugurate this program. Highly objectionable conditions will continue at and below the points of effluent discharge from the larger centers until this more efficient or secondary treatment is furnished.

This program for the treatment of sewage will not accomplish the desired objective unless concurrent action is taken to deal with the over-flows from combined sewers. These discharge large quantities of sewage and industrial wastes in times of heavy runoff. Generally, effective protection can be ensured by the use of adequate retention in sedimentation tanks followed by disinfection.

Similarly, the misuse or neglect of treatment facilities must be avoided at all times. Inefficient operation of the plant or bypassing of untreated or partially treated effluent must not be permitted.

The Board is of the opinion that reasonable stream sanitation consistent with the wide variety of uses of these waters, both present and future, will be maintained if the wastes are treated to a degree which will result in a median coliform M. P. N. value not exceeding 2,400 per 100 ml. at any point in the boundary waters following initial dilution of waste discharges. It will likewise be necessary to provide sufficient treatment that other substances which may injuriously affect the water, as defined in the objectives, will be removed.

Regional Sewerage Problems

Cooperation among the communities comprising a large center of population can be helpful in solving many mutual problems. The development of large metropolitan areas brings an increase in common governmental problems. Important among these are water supply and sewage disposal. Water distribution in such areas is generally less difficult than waste disposal. Fringe communities often must dispose of sewage through the major or parent community by virtue of natural drainage. Similar conditions may be true of the parent community discharging through other suburban areas of the drainage basin. Such regional problems are prominent at Detroit. Other areas on both sides of the boundary have problems of a similar nature.

A metropolitan or regional service for sewage disposal may be effected by one of two methods. Sewage disposal service may take the form of either contractual relations between the smaller communities and the larger one, or through the establishment of a quasi-municipal organization commonly known as a sanitary district. Experience in the United States has shown the sanitary district type of organization to be the more satisfactory for solving metropolitan sewerage problems. The usual enabling legislation authorizes revenue-producing powers in addition to normal governmental taxing ability and provides for equitable representation for the areas included. In Canada, both methods are being used successfully for providing water and sewerage services.

Reference has been made here to these methods of solving mutual sewage disposal problems in order that they may be considered in reaching a satisfactory solution in these areas of major populations.

Disposal of Industrial Wastes

The volume of industrial wastes, exclusive of that carried in municipal sewers, discharged directly into these boundary waters, is 1,430 million U. S. (1,191 million Imp.) gallons per day, nearly three times the volume of municipal wastes. As shown in table 16, chapter VII, these wastes carry large quantities of deleterious substances, which seriously affect the quality of the receiving waters and cause injury to health and property.

In contrast to the disposal of domestic sewage, industrial wastes are so varied in composition that no uniform treatment process is applicable. Each waste must be considered individually in the light of the deleterious substances present. Limits of tolerance for certain of these substances in industrial effluents have been included in the objectives for boundary waters quality control. The problem of industrial waste treatment is one for the industry involved.

When a new industry proposes to locate on a watercourse, due regard must be given to ensure that the wastes will not jeopardize the rights of other water users. The same principle must apply when new processes resulting in objectionable wastes are involved. This might properly take the form of approval by some public agency, a practice already in effect in both Michigan and Ontario.

One of the serious problems of industrial waste disposal is that of sudden or concentrated discharges, commonly known as "slugs" or "spills". By a slug is meant the release of a volume of highly concentrated polluting material over a short period of time. Slugs are intermittent, but their effects may be felt for great distances and for prolonged periods.

Slugs cause difficulty in producing an acceptable water supply. Since operators of water purification plants have no warnings of the approach of this material, some may enter the distribution system before adequate treatment can be applied. This situation presents a constant health hazard and may render the water unacceptable in other respects. For example, a sudden increase in the chlorine demand may result in a drinking water not properly disinfected. The worse offenders are industries using intermittent operations or other methods which result in periodic discharges. Slugs are usually due to deliberate discharge of waste materials, in contrast to spills resulting from accidents.

It is the responsibility of industry to avoid slugs and spills as far as possible. Retention tanks or lagoons should be provided where such conditions prevail, so that the discharges will be equalized.

Disposal of Other Wastes

Other wastes originate chiefly from navigation, dredging, and refuse disposal. While these wastes are of secondary importance they are significant in contributing to the pollution of boundary waters.

Vessels add pollution through the discharge of sewage, bilge water, and ballast water. They contribute bacterial pollution and oils to restricted areas, such as near water works intakes and bathing beaches. These discharges may also endanger the safety of water supplies taken aboard by other vessels while en route. This objectionable practice can be corrected by the use of sewage retention tanks accompanied by some form of sterilization of the contents. The tanks should be emptied either by transfer to shore treatment facilities or dumped overboard in non-restricted areas after adequate disinfection of the contents. This requirement should apply to commercial vessels equipped with flush toilets and to craft used for living purposes.

Much can be accomplished in reducing pollution from bilge and ballast waters by selecting non-restricted areas for their discharge. These restricted areas are or can be defined by legislation.

Dredging operations should involve the selection of dumping grounds which will not interfere with legitimate water uses, nor result in the transboundary travel of the dumped material.

Because garbage and other refuse cause unsightly conditions in water they should not be dumped either from shore points or overboard from vessels. Boats should provide facilities for storing this material for subsequent disposal on land. Local agencies should endeavor to control dumping from shore by careless persons.

Progress In Pollution Control

Progress in the control or elimination of pollution has been substantial during the period of this investigation. Both municipalities and industries have contributed to this activity. Several factors have been responsible for this, such as availability of materials following termination of the war, stimulation by state and provincial authorities and interest of sportsmen's organizations, research into waste disposal methods, and the activities associated with this investigation. As an example, it may be noted that taste difficulties in municipal water supplies were much less pronounced at the conclusion of this study than prior to 1946.

While construction of sewage works has not been on a large scale there has been much activity in the preparation of plans and initiation of projects. Industrial waste treatment has made a pronounced advance. At the time of the hearings in 1948 it was estimated that industry had spent about $5,000,000 on corrective measures on both sides of the boundary since the initiation of the investigation. This activity is continuing on the part both of municipalities and industries.

Present Status of Municipal Waste Treatment

The present status of waste treatment programs for the Michigan municipalities is as follows:

St. Clair River Area

Municipality	*Present Status*
Port Huron	No treatment. Construction plans for interceptors and primary treatment completed. Under order of Michigan Supreme Court.
Marysville	No treatment. Construction plans for interceptors and primary treatment in progress.
St. Clair	No treatment. Construction plans for interceptors and primary treatment in progress.
Marine City	No treatment. Construction plans for interceptors and primary treatment in progress.
Algonac	No Treatment. Report on corrective measures in progress.

Lake St. Clair Area

Municipality	*Present Status*
New Baltimore	No treatment. Construction plans for complete treatment completed.
Mt. Clemens	No treatment. Construction of complete treatment facilities under way.
St. Clair Shores	To Detroit Plant. Construction plans for additional collection completed.
Roseville	To Detroit Plant.
East Detroit	To Detroit Plant. Increase in sewage interception under study.
Centerline	To Detroit plant. Additional interceptor needs under study.
Warren Township	To Detroit Plant. Construction plans for additional collection completed.
Grosse Pte. Woods	To Detroit Plant.
Grosse Pte. Shores	To Detroit Plant. Construction plans for additional collection completed.
Grosse Pte. Farms	To Detroit Plant.
Grosse Pte.	To Detroit Plant.
Grosse Pte. Park	To Detroit Plant.

Detroit River Area

Municipality	*Present Status*
Detroit	Primary treatment with partial effluent disinfection in operation. Construction plans for additional interceptors completed. Construction of some interceptor facilities under way. Further treatment under consideration.
Highland Park	To Detroit Plant.
Hamtramck	To Detroit Plant.
Dearborn	Primary treatment without effluent disinfection in operation. No plans for plant enlargement or improved treatment.
Melvindale	No treatment. Construction plans for interceptors and primary treatment completed.
River Rouge	To Wyandotte Plant.

Municipality	*Present Status*
Ecorse	To Wyandotte Plant. Construction of additional collecting sewers under way.
Allen Park	To Wyandotte Plant.
Lincoln Park	To Wyandotte Plant.
Wyandotte	Primary treatment with effluent disinfection. No plans for plant enlargement. Construction plans for additional interceptors completed.
Riverview	To Wyandotte Plant.
Trenton	Primary treatment with effluent disinfection.

In Ontario the present status of the sewerage programs for the boundary municipalities is as follows:

	St. Clair River Area
Sarnia	No treatment. Engineering report and preliminary plans completed for interceptor and primary treatment.
Sarnia Township	No treatment. Preliminary studies under way.
	Lake St. Clair Area
Wallaceburg	No treatment. Engineering report and preliminary plans completed for collection system and primary treatment.
Chatham	No treatment. Studies made for interceptors and sewage treatment.
	Detroit River Area
Tecumseh	No treatment. Engineering report and preliminary plans completed for sewers and treatment plant.
Riverside	Secondary treatment in operation.
Sandwich East Township	No treatment. Will be incorporated in greater Windsor system.
Sandwich West Township	No treatment. Will be incorporated in greater Windsor system.
Windsor	No treatment. Preliminary studies made on interceptors and sewage treatment.
Amherstburg	No treatment. No plans or report.

Present Status of Industrial Waste Treatment

The status of industrial waste treatment programs on each side of the boundary is presented below. This status is indicated by a key number as follows:

(1) Control measures provided.
(2) Control measures provided. Adequacy not demonstrated.
(3) Municipal sewerage facilities utilized.
(4) Studies, plans, or construction under way.
(5) No progress indicated.
* Actual construction under way.

In Michigan industries the status is as follows:

Industry	*Class*
Allied Chemical and Dye Corp., Barrett Division	
Oil Waste	(2)
Sewage	(3)
Phenol and others	(4)
Allied Chemical and Dye Corp., General Chemicals Div.	(4)
Allied Chemical and Dye Corp., Semet-Solvay Div.	
Sewage	(4)
Industrial Waste	(4)
Allied Chemical and Dye Corp., Solvay Process Div.	
Sewage	(4)
Industrial Waste	(2)
American Agricultural Chemicals Co.	
Sewage	(3)
Industrial Waste	(4)
American Brass Co.	
Sewage	(3)
Industrial Waste	(2)
Darling & Co.	
Sewage	(4)
Industrial Waste	(2)
Detroit Edison Co. (Marysville gas plant)	(2)
Detroit Michigan Stove Co.	
Sewage	(3)
Industrial Waste	(3)
Detroit Sulphite Pulp and Paper Co.	
*Sewage	(4)
*Industrial Waste	(4)
Diamond Crystal Salt Co.	
Sewage	(4)
Industrial Waste	(2)
Dunn Paper Co.	
Sewage	(5)
Industrial Waste	(2)
E. I. DuPont de Nemours & Co., Electrochemicals Dept.	
Sewage	(3)
*Industrial Waste	(4)
E. I. DuPont de Nemours & Co., Grasselli Chemicals Dept.	
*Sewage	(4)
Industrial Waste	(1)

Industry	*Class*
Firestone Rubber & Metal Products Co.	
Sewage	(3)
*Oil Waste	(4)
*Acid Waste	(4)
Ford Motor Co., Rouge Plant	
Sewage	(3)
*Acid Waste	(4)
*Oil Waste	(4)
*Cyanide Waste	(4)
*Phenol Waste	(4)
Franklin County Sugar Co.	(4)
Fuel Oil Corp.	(2)
Great Lakes Engineering Corp.	
Sewage	(5)
Oil	(2)
Great Lakes Steel Corp.	
*Sewage	(3)
Oil	(4)
Acid	(4)
Halowax Corp.	
Sewage	(3)
Acid Waste	(5)
Michigan Consolidated Gas Co. Rouge Station	(2)
Michigan Consolidated Gas Co. Station A	(2)
Michigan Consolidated Gas Co. Station B	(2)
Monsanto Chemical Co.	
Sewage	(3)
Industrial Waste	(2)
Morton Salt Co.	
Sewage	(4)
Industrial Waste	(2)
Murray Corporation of America	
Sewage	(5)
Oil	(4)
Acid	(2)
Parke-Davis Co.	
Sewage	(3)
Industrial Waste	(2)
Peerless Portland Cement Co.	
Sewage	(3)
Industrial Waste	(5)
Pennsylvania Salt Co.	
Sewage	(3)
Industrial Waste	(2)
Port Huron Sulphite & Paper Co.	(4)
Pressed Metals Company of America	(5)
Reichhold Chemicals Inc.	(4)
Revere Copper & Brass	
Sewage	(3)
Industrial Waste	(4)
Sharples Chemicals, Inc.	
Sewage	(3)
Industrial Waste	(2)
Socony-Vacuum Oil Co.	(1)
U. S. Rubber Co.	
Sewage	(3)
Industrial Waste	(2)
Werner G. Smith Co.	
Sewage	(3)
*Industrial Waste	(4)
Wyandotte Chemicals Corp., North Works	
*Sewage	(4)
Industrial Waste	(2)
Wyandotte Chemicals Corp., South Works	
Sewage	(4)
Industrial Waste	(2)

In Ontario the present status of industrial waste treatment programs is summarized as follows:

Industry	*Class*
Dominion Salt Co.	
Sewage	(2)
Industrial Waste	(2)
Imperial Oil Limited	
Sewage	(4)
Oil Waste	(2)
*Phenol	(4)
Caustic	(1)
Mueller Limited	
Sewage	(4)
Cyanides	(2)
Chrome	(2)
Union Gas Co.	
Sewage	(4)
Oil	(4)
Phenols	(2)
Polymer Corp.	
Sewage	(2)
Oil	(2)
*Styrene	(4)
Caustic	(5)
Acid	(5)
Dow Chemical	
Sewage	(4)
*Industrial Waste	(4)
H. J. Heinz Co. of Canada Limited	
Sewage	(2)
Industrial Waste	(4)
Sydenham Trading Co.	
Sewage	(2)
Cyanide	(2)
Wallaceburg Brass	
Sewage	(2)
Industrial Waste	(2)
Canada & Dominion Sugar Co. Limited (Wallaceburg Plant)	
Sewage	(2)
Industrial Waste	(4)
Canada & Dominion Sugar Co. Limited	

Industry	*Class*
(Chatham Plant)	
Sewage	(2)
Industrial Waste	(4)
Darling and Company	
Sewage	(3)
Industrial Waste	(2)
Ford Motor Co. of Canada	
Sewage	(3)
Acid	(4)
Oil	(4)
Hiram Walker and Sons Limited	
Sewage	(3)
Industrial Waste	(4)
Canadian Industries Limited	
Sewage	(4)
Industrial Waste	(2)
Canadian Steel Corp.	
Sewage	(5)
Acid	(5)
Iron	(5)
Brunner Mond. (Canada) Limited	
Sewage	(5)
Industrial Waste	(5)
Calvert Distillers (Canada) Limited	
Sewage	(4)
Industrial Waste	(4)

Costs and Financing

The following estimates have been prepared on costs for remedial measures in answer to this question in the terms of reference. The municipal costs are divided as follows: (1) interceptors and primary treatment, (2) addition of secondary treatment. For industries the costs are estimated on the basis of compliance with the objectives for boundary waters quality control.

Costs for municipalities (interceptors and primary treatment):	
United States side	$ 35,000,000
Canadian side	16,000,000
Total Municipal	$ 51,000,000
Costs for industries:	
United States side	$ 13,000,000
Canadian side	3,000,000
Total Industrial	$ 16,000,000
Total	$ 67,000,000

For the second stage or secondary treatment of municipal wastes the additional costs are estimated as:

United States side	$ 33,000,000
Canadian side	4,000,000
Total	$ 37,000,000
GRAND TOTAL	$104,000,000

A strong deterrent in the solution of water pollution problems has been the reluctance of municipalities and industry to make funds available for this purpose. This may be due either to financial inability, lack of appreciation of responsibility by the polluter, or indifference on the part of the public. Accordingly, it is important to consider methods of securing funds for the construction and operation of remedial works.

Remedial works for treating municipal wastes must be constructed through public funds. These may come from any of several sources such as cash reserves, short term loans or debentures, general obligation bonds, special assessment bonds, revenue bonds, government aid, or any combination of these. The annual payments on capital debts incurred by the municipalities for such works and for their operation may come from general taxation or some form of service charge. Since the sewage works are designed for the benefit of the entire community and are an obligation of the municipality some municipal authorities favor paying part of the costs by general taxes. In order to apportion the remaining costs on the basis of benefits derived the practice of applying a service charge is gaining widespread use. These service charges are designated by several names such as sewer rates, sewage service rates, and sewer rentals. These rates have advantages which justify serious study by public officials confronted with the problem of financing municipal sewage treatment works.

It is a recognized fact that industrial wastes are the responsibility of the industry. Experience has demonstrated that in certain industries it is possible to reclaim from the wastes useful by-products which offset the cost of disposal. The treatment or control of these wastes, however, whether profitable or otherwise, must be regarded as a part of the cost of production.

Legislation On Pollution Control

Legislation applicable to water pollution control was reviewed in chapter V. It defines Federal, State and Provincial, and municipal responsibilities and jurisdictions.

Federal legislation in the United States centers about Public Law No. 845, passed in 1948, and known as the "Water Pollution Control Act." It was designed "to provide Federal technical services to State and interstate agencies and to industries, and financial aid to State and interstate agencies and to municipalities in the formulation and execution of their stream pollution abatement programs." There is also Federal legislation applicable to certain types of pollution entering harbors and other navigable waters.

In Canada there is no Federal legislation which is concerned with pollution of water per se. There are, however, certain statutes which deal with this problem, particularly as applied to navigation, fisheries, and wild life.

In the state of Michigan, pollution control is centered in the Water Resources Commission. The statute creating this agency gives authority to deal with all types of pollution.

In the Province of Ontario, legislation applicable to pollution control is contained in The Public Health Act and other enactments.

Municipalities are authorized to enact regulations or by-laws dealing with such local matters as control of pollution, restrictions on the use of sewers, setting sewer service rates, and financing.

The Continuing Program

It is recognized that in these waters pollution control is an ever changing problem. The fulfillment of the objective will require time and continuous supervision. Technical difficulties may be expected in connection with industrial wastes. New industrial processes which will be developed may produce different wastes and complications in disposal. Past experience has shown that constant effort and attention by regulatory authorities are needed if existing pollution is to be controlled and new pollution is to be prevented.

It is believed advisable for the Commission to foster pollution abatement programs for the boundary waters through consultation and cooperation with Federal, State, and Provincial governments. The administration of such a program should be through existing pollution abatement authorities.

A spirit of cooperation in solving pollution problems has been evident particularly among industries. Such cooperation has also been shown by the municipalities, but it has been less productive largely because of financial difficulties. Many large industrial concerns are undertaking their own pollution research and abatement programs on a national scale. Other industries have formed into groups or associations primarily for the development of waste treatment methods. Such groups include the Manufacturing Chemists Association of the United States, the American Petroleum Institute, the National Council for Stream Improvement (of the Pulp, Paper and Paperboard Industries) Incorporated, and the American Iron and Steel Institute.

It is believed that progress in pollution abatement will be aided if a technical committee or board be established to maintain a continuing interest in the pollution problem. Such a committee would supplement and strengthen the efforts made by local authorities and would permit the interchange of reports on progress. This committee should consist of representatives from the Federal, State, and Provincial governments involved in this problem.

LAKE SUPERIOR—LAKE HURON SECTION

1946-1948

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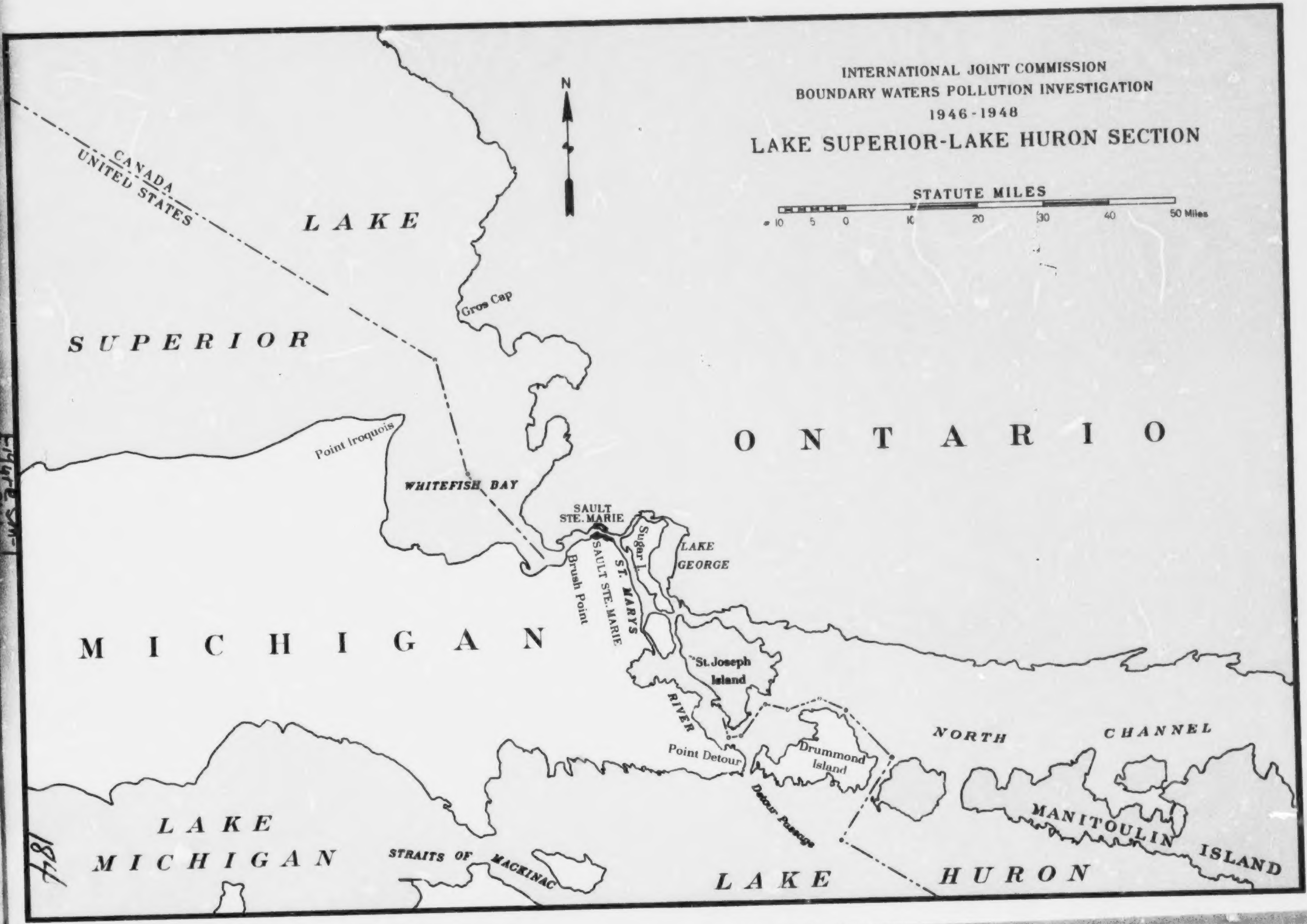

N
STATUTE MILES
10 5 0 10 20 30 40 50 Miles
CANADA
UNITED STATES
LAKE SUPERIOR
Gros Cap
Point Iroquois
WHITEFISH BAY
ONTARIO
SAULT STE. MARIE
SAULT STE. MARIE
Brush Point
Sugar I.
LAKE GEORGE
ST. MARYS RIVER
St. Joseph Island
MICHIGAN
Point Detour
Drummond Island
Detour Passage
NORTH CHANNEL
MANITOULIN ISLAND
LAKE HURON
LAKE MICHIGAN
STRAITS OF MACKINAC

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946-1948

LAKE SUPERIOR-LAKE HURON SECTION

Chapter SM-I

FINDINGS AND RECOMMENDATIONS

The investigation of pollution in the boundary waters of the Lake Superior-Lake Huron section has extended over the period of July 1947 to July 1948. In that time a comprehensive examination was made of all phases of pollution, and relevant information was obtained from several sources. These data have been studied and conclusions reached on the questions contained in the terms of reference to the International Joint Commission by the governments of the two countries.

The investigation has enabled the Board of Technical Advisers to reach certain conclusions on the findings and to offer recommendations to the Commission for remedial measures. The findings of the Board are discussed in chapter SM-VIII and are summarized herewith.

Findings

1. These waters are polluted in many places on both sides of the boundary. The most serious pollution occurs in the river from the locks to the head of Sugar Island and in the Lake George Channel.
2. There is a transfer of pollution from each side of the boundary to the other. This occurs chiefly in the Lake George Channel.
3. There has been injury to health and property on both sides of the boundary. This has been manifested in the following ways:
   a. Health—A potential hazard exists where waters polluted to the extent of these are used for domestic purposes. The present raw water supplies on both sides of the boundary are relatively free from heavy bacterial pollution but cannot be used without complete and continuously effective treatment. Much of the threat to health arises from such factors as variations in pollution with accompanying erratic chlorine demand, interference of certain types of pollution with disinfectants which destroy their germicidal properties, and the probability of certain infections being carried through a treatment process if there is any interruption or breakdown in a part of that process.

   These waters are so polluted in certain areas as to render them unsafe for bathing purposes. This hazard is not only associated with typhoid fever and other reportable diseases, but it may include enteric, ear and upper respiratory infections.

   The sewage pollution present in these boundary waters must be considered as an actual and potential health hazard, whether it be through public water supplies, bathing beaches, or other vectors.

   b. Property—Injury to property has been illustrated in the deposition of solids of waste origin on waterfront property, interference with the development of bathing beaches and other waterfront property, additional cost of water treatment and fouling of shore areas by oil.
4. Limited progress has been made toward the control of pollution during the period of this investigation.
5. Public hearings held by the Commission revealed a common acceptance, on the part of municipal officials and industrial management, of the presence of pollution in these waters and the need for correction. Financing of the necessary remedial works was asserted by municipal officials to be the principal obstacle to correction.
6. Frequent releases of pollution in the form of slugs or spills create intensified injury to the users of these waters and cause acute difficulties in water purification plants.
7. The condition of these waters requires that remedial measures be undertaken as early as possible.

Recommendations

The Advisory Board respectfully offers the following recommendations to the Commission:

1. Remedial measures for the abatement and and control of pollution in the Lake Superior-Lake Huron section of the boundary waters must be undertaken at the earliest possible date. These measures should be sufficient to restore and protect the uses of these waters to which the people of both countries are rightfully entitled. Major consideration should be given to uses for domestic and industrial water supplies, recreation, fish and wildlife, sanitary purposes, and navigation.
2. The "Objectives for Boundary Waters Quality Control," prescribed in this report be recognized in the development of remedial and pollution-preventive measures by mu-

nicipalities and industry. These objectives should apply to both existing and new sources of wastes.

3. Treatment of municipal wastes by sedimentation and disinfection of the effluent be undertaken by both municipalities as the initial step. The estimated cost for installation of intercepting sewers and primary treatment works for the two municipalities in this section is $4,000,000 of which $1,250,000 is on the United States side and $2,750,000 on the Canadian side.
4. Industrial wastes be treated to comply, as soon as possible, with the "Objectives for Boundary Waters Quality Control." The estimated cost for industrial waste treatment works is $500,000 of which $150,000 is for United States and $350,000 for Canadian industries. The correction and prevention of pollution resulting from the disposal of industrial wastes is the responsibility of industry.
5. Slugs and spills of objectionable wastes from industrial plants be avoided. Retention tanks or lagoons for equalizing rates of discharge may be utilized when approved by enforcing authorities where slugs and spills cannot otherwise be controlled.
6. Sewage from vessels equipped with flush toilets and from craft used for living purposes be controlled by the installation of holding tanks, and that the tanks be emptied either by transfer of the contents to shore treatment facilities or dumped overboard in non-restricted areas after disinfection. Bilge and ballast waters be discharged only in non-restricted areas. No garbage or other refuse be discharged overboard into these waters.
7. Definite plans for financing remedial municipal works be formulated. In this, there should be cooperation between the Commission and Federal, State, Provincial, and municipal governments.
8. Continuing contact with pollution control progress be maintained through a technical committee or board having representation from both countries.
9. The Commission take such measures as may be legally available to it to have the pollution abatement and prevention program herein outlined initiated, promoted, and effectively prosecuted.

Chapter SM-II

INITIATION OF THE INVESTIGATION

The Pollution Problem

In the 1913 investigation all sections of the boundary waters were included, from the Lake of the Woods on the west to the St. Lawrence River on the east. In the present investigation only parts of the boundary waters are involved, particularly those contiguous to large centers of population or major industrial developments. The discharge of untreated municipal and industrial wastes which appeared to have international significance, precipitated this investigation of the St. Marys River.

Authorization of Survey

The reference covering the St. Marys River is an extension of the reference to the Commission on the St. Clair River, Lake St. Clair and the Detroit River. The terms of reference, dated October 2, 1946, are the same as those for the Lake Huron-Lake Erie section. The Commission, accordingly, requested the same Board of Technical Advisers to extend their investigational activities to this section of the boundary waters. This territory is designated in this report as the Lake Superior-Lake Huron section.

Organization for Lake Superior-Lake Huron Investigation

Field work on the Lake Superior-Lake Huron section was initiated in July 1947. The personnel for this work was supplied by Federal, State and Provincial agencies, the same as for the Lake Huron-Lake Erie section.

Field laboratories were established at Sault Ste. Marie, Ontario, and at Sault Ste. Marie, Michigan. The entire section was examined by both field parties in close co-operation. Field studies included sampling and analysis of the boundary waters, visual examination, and investigation of industries and other sources of pollution. Special examinations and studies were made in the laboratories of the Ontario Department of Health at Toronto and of the U. S. Public Health Service at Cincinnati, Ohio.

The general laboratory techniques and procedures followed were the same as those used for the Lake Huron-Lake Erie section. The number of samples collected and analyses made are listed in table SM-1.

TABLE SM-1—SAMPLES COLLECTED AND ANALYSES MADE

Area or Source	Bacteriological Examinations	Chemical Examinations	
		Samples	Determinations
Upper St. Marys River	679	533	2,939
Lower St. Marys River	1,602	1,426	7,371
Municipalities	214	214	214
Industries	....	50	342
Total	2,495	2,223	10,866

Selection and Designation of Sampling Points

The same principles were followed in the selection of sampling points as in the Lake Huron-Lake Erie section. The 1913 sampling points were used and others added as the situation required.

The river mileage index system was employed to designate the locations of sampling ranges, sewer outlets, and other important points on the river. These reference points refer to the zero mileage point established by the U. S. Corps of Engineers at the upstream end of the United States locks at Sault Ste. Marie. All distances were taken as either upstream or downstream from this point. The letters used for designation of ranges are SMU for upstream and SMD for downstream from the zero point.

Chapter SM-III

GENERAL DESCRIPTION AND HYDROMETRIC DATA

The drainage basin of the Lake Superior-Lake Huron section embraces a relatively small and sparsely settled region on both sides of the International Boundary. It drains an area of 1,949 square miles, with 808 in the United States and 1,141 in Canada. Numerous small streams drain into the river along its course, but none of them is of sufficient importance to warrant special discussion. The geographical features of the area are shown in figure SM-1 (following page 184).

St. Marys River Basin

St. Marys River is the connecting waterway between Lake Superior and Lake Huron. It flows from Lake Superior in an easterly direction to Sault Ste. Marie and then southeasterly to Lake Huron. The upper river section is short, extending from Whitefish Bay to St. Marys Falls, a distance of 14 miles. This section of the river varies in width from 18,000 feet at Whitefish Bay to 2,000 feet at the falls and has channel depths ranging from 25 to 55 feet. The falls of the St. Marys River are about ¾ mile long and ¼ mile wide, and the drop ranges from 18 to 24 feet with stages of water surface.

Since 1797, when the first lock was built on the Canadian side, a series of works has been constructed on both the United States and Canadian sides of the falls, as aids to navigation and for power development. These works include dredged channels, locks, power diversion canals and regulating gates at the head of the rapids.

Below the falls, the river to Lake Huron consists of a series of interconnected lakes and bays which form an irregular shore line. This section of the river extends for a distance of 49 miles from the locks to Detour Passage via the main vessel route through Lake Nicolet Channel and about 61 miles via Lake George Channel. The lower river contains three large islands, Sugar and Neebish Islands on the United States side, and St. Joseph Island on the Canadian side. These split the flow of the river into the various channels. Early navigation was through the Lake George Channel, although the available depth was only 4 to 5 feet. The other channels were closed to navigation by the Neebish Rapids which were shallow and full of rocks. The Lake George Channel, largely in Canadian waters, has been abandoned and a nearly continuous channel improvement project has been completed by the United States through Lake Nicolet and the Middle and West Neebish Channels. Vessel traffic now uses this latter route almost exclusively.

The area on the Canadian side, draining to the section of the St. Marys River from Lake Superior to Lake George, is relatively narrow and reaches from 8 to 10 miles inland. The area draining into the river below Lake George comprises the much greater portion of the entire drainage basin. This portion extends inland a maximum distance of approximately 45 miles.

Natural drainage on the United States side flows to the St. Marys River in several small streams which have their headwaters only a few miles inland. The largest of these tributaries is the Munuscong River, which drains a local watershed extending to a depth of about 15 miles inland. These tributaries are of no commercial importance and hence require no dredging. They have primary value as recreational areas and are retained in their original state as wildfowl refuges.

Topography

The area in Ontario which borders the St. Marys River is a drift-covered strip, varying from one to five miles in width. In the central and west portion it rises toward the north in a succession of clay, sand, and gravel terraces. It reaches a maximum altitude of about 400 feet above mean water surface elevation of 602.2 feet in Lake Superior. The area to the north of the lower terraced section rises to an altitude of 420 feet above mean water surface elevation of 579.8 feet in Lake Huron. On the United States side the topography is characterized by gradually rising terrain from the river to the inland headwaters. Extending westward beyond the headwaters of the tributaries, the rising terrain develops into a flat area which is generally less than 300 feet above the bordering lakes.

Geology

The St. Marys River came into existence in comparatively recent times. In preglacial time the outflow from the Superior basin was south from Whitefish Bay. It passed through a channel near the present village of Rudyard to St. Martin Bay and joined Spencers Laurentian River north of Bois Blanc Island. During the early postglacial period Lake Superior stood at the same elevation as Lake Michigan-Huron, the connection being a broad strait in the present St. Marys valley. Differential movement in the crust of the earth finally raised the rock ledge at Sault Ste. Marie above the level of Lake Huron, and the strait became the St. Marys River.

The rock formations of the area range from pre-Huronian to Cambrian. The oldest series consist of steeply tilted schists, which are intruded by granite and diabases, also pre-Huronian in age. The hard rock formations of the area are manteled and, in places, are deeply buried beneath a covering of drift. This, in turn, is overlain by lake clays, silts, sands, and gravels. The latter cover the lowlands and extend up the slopes to a height of over 400 feet in western Ontario.

Climate

The climate of the region is subject to considerable variation, similar to that of the Lake Huron-Lake Erie section. However, the mean annual temperature is about 10°F. lower than that in the more southerly part. The proximity of Lakes Superior, Michigan, and Huron tempers the climate decidedly along their shores. This is especially true of the narrow strip along the south shore of Lake Superior. The typical North American cold wave, which so frequently sweeps down from the northwest and is attended by strong northwest winds, is tempered in severity as it crosses the wide stretches of comparatively warm water. The temperature is often raised from 15° to 20°F. in this way, so that the region immediately bordering Lake Superior does not experience the extremely low temperature conditions that are common further inland.

The average annual temperature at Sault Ste. Marie, Michigan, for 55 years of record, was 38.1° F. The extremes range from 98° to minus 37°F., with an average temperature in February of 11.5°F. and an average temperature in July of 62.7°F. The average annual precipitation, for 52 years of record at this location was 29.88 inches, with a maximum of 41.02 and a minimum of 20.69 inches. The greater portion of this precipitation falls during the growing season. One characteristic of the weather along Lake Superior is the heavy snowfall. This averages more than 100 inches per winter, while at Sault Ste. Marie it averages 80 inches. The prevailing winds are from the northwest for eight months of the year, February through September, and from the southeast for four months, October through January. The average hourly velocity of the prevailing winds was 8.6 miles. A maximum velocity of 56 miles per hour was recorded with a northwest wind in February 1889.

Population

The population in the drainage basin of the St. Marys River, given in the 1940 U. S. Census and 1941 Canadian Census, was 63,000. More recent estimates (1948) indicate a population increase of about 2,600 on the Canadian side and 1,500 on the United States side since 1940. This makes the present estimated population in the area over 67,000. Figure SM-2 shows the growth in population between 1910 and 1948.

Sault Ste. Marie, Michigan, and Sault Ste. Marie, Ontario, are the two principal population centers in the area. In 1948 the combined estimated population of these two cities was 47,000, about two-thirds of the total population in the drainage basin. The rural population is distributed in small villages with less than 1,000 persons and in isolated homesteads throughout the township areas. The population density in 1948, expressed in persons per square mile, was about 35 in both the United States and Canadian areas and for the entire basin.

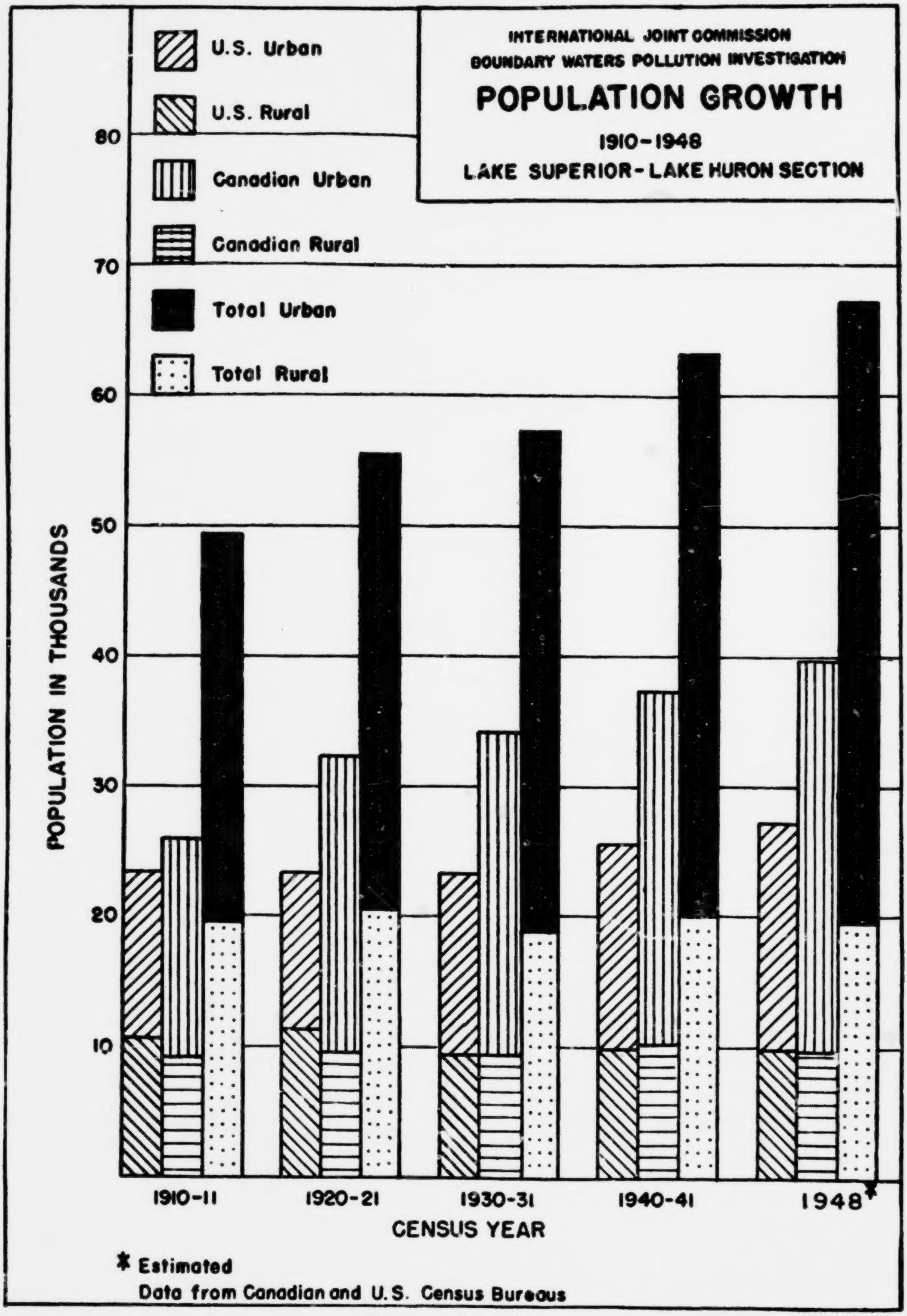
Land Use and Development

The Upper Peninsula of Michigan, including the eastern portion in the St. Marys River basin, was originally covered with heavy forests of pine and hardwoods. A great part of these forests have been cut away. Early development in the area was due principally to the lumbering activities. Construction of the locks and other facilities related to the improvement of the St. Marys River as a commercial waterway also contributed to the growth. Early development of hydroelectric power plants on both sides of the St. Marys Falls resulted in the growth of an industrial area. The major industries in the area include a steel mill, a pulp and paper mill, a tar and chemical plant, carbide manufacturing, and leather processing plant.

The cut-over land surrounding the centers of population has been developed for agriculture. The principal agricultural crops are hay, small grains, and potatoes. Lumbering operations are still carried on in the virgin timber area to the northeast of Sault Ste. Marie, Ontario. In more recent years, limited operations have been renewed in the second-growth timber areas of the Upper Peninsula in Michigan. Sugar Island is wooded and rocky and has numerous summer cottages along its shore. St. Joseph Island has been developed primarily for agriculture. Both of these islands are linked to the mainland by car ferries.

Hydrometric Data

The discharge of the river is now subject to regulation and the flow is varied according to


INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
POPULATION GROWTH
1910–1948
LAKE SUPERIOR - LAKE HURON SECTION

* Estimated
Data from Canadian and U.S. Census Bureaus

Figure SM – 2

water level requirements. Since the development of hydroelectric power plants on both sides of St. Marys Falls, the portion of the total flow diverted for power purposes is so controlled as to maintain a required level in Lake Superior and also to maintain adequate channel depths for navigation purposes in the lower river. When the water surface of Lake Huron is high, the current in St. Marys River is checked. When a large flow is passed from Lake Superior, the current is strong and is further increased if the level of Lake Huron is low.

River discharge data, compiled by the U. S. Lake Survey, show the flow averaged 72,600 c.f.s. for the 48-year period 1900-1947. In the upper section, above the falls, the current velocities are less than 1 mile per hour. Below the falls the swiftest currents in the navigable channels are found in the Middle Neebish dike, the West Neebish rock cut, and the Little Rapids cut. Velocities in these channels are usually 1½ to 2 miles per hour but vary from a low of 1 mile to a high of 3 to 3½ miles per hour. The present fall from the foot of the rapids to Lake Huron averages about 1½ feet. Under present conditions the Lake George Channel carries about 32 percent of the river flow, with the remainder passing down the Lake Nicolet and Neebish Channels.

Chapter SM-IV

USES OF BOUNDARY WATERS

The waters in the Lake Superior-Lake Huron section of the boundary are used for a variety of purposes. The order of precedence to be given to these uses is stated in Article VIII of the treaty of 1909 between the two countries. These waters serve for domestic and sanitary purposes, navigation, power and irrigation. Others uses are for industrial process water, recreation, and for support of fish and wildlife. Irrespective of the uses made, the treaty requires that these boundary waters shall not be polluted on either side to the injury of health or property on the other side.

Domestic Water Supply

The waters of the upper St. Marys River are the sources of supply for the cities of Sault Ste. Marie. The water is not filtered but is chlorinated at both cities. On the Ontario side ammonia is used for control of chlorophenolic tastes. A portion of the Canadian city is supplied with well water, and about 45,000 persons in the two cities are supplied with water from the river. The total average pumpage for each plant is:

Canadian	2.7 M.G.D. (Imp.)
United States	5.5 M.G.D. (U.S.)

Much of the water from the Michigan plant goes to industry. The industries on the Ontario side pump their own process water. No public water supplies are taken from the lower St. Marys River.

Sanitary Purposes

The river is used for the disposal of the untreated domestic sewage from the entire population of both cities. It reaches the river through numerous outlets, nearly all of which are below the locks.

Navigation

Vessel traffic through this section is very heavy. In the 1947 season of navigation the vessel passages amounted to 22,270, passengers carried 90,500, and total tonnage carried 83,300,000 tons. These waters are used for disposal of all sanitary wastes from these vessels. At times, vessels are forced to anchor close together, both above and below the locks, thereby imposing a more concentrated pollution load on the river.

Power and Irrigation

The water is used for power purposes on both sides of the boundary. This affects the currents in the river but it does not add pollution.

Industrial Uses

Industry in this area uses the boundary waters for process, steam power, cooling and sanitary purposes, in addition to that taken from public supplies. The water so pumped from the river for industrial uses amounted to 98 million U. S. (82 million Imp.) gallons. This water is returned to the river as waste through independent plant outlets.

Recreational Uses

The many lakes and bays in the lower river provide areas with excellent bathing possibilities, but these have been developed only to a limited extent. The only public recreational development along the lower river, within easy reach of the city populations, is the municipal park east of Sault Ste. Marie, Ontario. This park is deprived of bathing privileges because of pollution. A public park is located on the Michigan side near the upper city limits and above the locks, but bathing is limited. There is private bathing in all parts of the river other than in the immediate vicinity of the two cities.

Boating and fishing are popular forms of recreation throughout the entire area. While bathing is restricted to a comparatively short season because of low water temperature, fishing is continued almost the year round.

Legislation

Legislative authority for control of pollution in this section is the same as that in the Lake Huron-Lake Erie section.

Chapter SM-V

WATER-BORNE DISEASES

Consideration has been given to the incidence of typhoid fever and dysentery in relation to water pollution. In the appendix to the Progress Report of the International Joint Commission dated January 16, 1914, it is stated that the typhoid fever rates were high in both cities. When Sault Ste. Marie, Michigan, took its water supply from just above the locks in the old ship canal, its typhoid fever rate paralleled that of Sault Ste. Marie, Ontario. When it moved the intake to a location well above the city, its rate fell markedly below that of the Ontario city. In the winter, the typhoid fever rate dropped to almost nil but rose strikingly during the months of navigation. In Sault Ste. Marie, Ontario, typhoid was present in winter as well as summer. These facts were taken as an illustration of the disastrous effect of slight intermittent pollution and pollution from boats. At that time neither city had chlorination of its water supply.

Both city water supplies from the river have been chlorinated for many years, and a marked reduction in typhoid fever rates has occurred. Similar pollution exists today, but chlorination is the protective barrier against water-borne disease. The typhoid fever death rate, accordingly, is no longer an index of the sanitary quality of this water. Table SM-2 shows the statistics on typhoid fever deaths from 1913 to 1947.

TABLE SM-2—TYPHOID FEVER MORTALITY

Total Deaths and Death Rates Per 100,000 Population

Municipality	1913		1920		1930		1940		1947	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
State of Michigan	558	17.5	300	8.2	89	1.8	11	0.2	5	0.08
Sault Ste. Marie, Mich	3	24.1	0	0	1	7.3	0	0	0	0
Province of Ontario	446	16.7	203	7.0	76	2.3	26	0.7	6	0.1
Sault Ste. Marie, Ont	16	124.0	3	13.9	0	0	0	0	0	0

Chapter SM-VI

SOURCES AND CHARACTER OF POLLUTION

Pollution entering the boundary waters in this section originates principally from domestic and industrial sources at Sault Ste. Marie, Michigan, and Sault Ste. Marie, Ontario. Both the the municipal and industrial sewers discharge untreated into the St. Marys River through multiple outlets. Pollution from tributaries is relatively unimportant as such streams are small and drain only rural areas and unsewered communities.

There are 5 major industrial plants located in the district, 2 of them in the United States and 3 in Canada. Detailed studies were made of the character and volume of wastes produced at the 3 Canadian plants. The wastes from 1 industrial process on the United States side were considered of little significance, and no studies were made. In the other industry, information obtained from State records and from engineering conferences was deemed sufficient.

Vessels engaged in freight and passenger traffic in this section also constitute a source of pollution. Its significance is indicated by the fact that the canals at Sault Ste. Marie handle, during the navigation season, twice the yearly tonnage of the Panama Canal.

Domestic Wastes

The principal source of sewage pollution is the domestic wastes discharged from both cities through combined sewers into the St. Marys River, mostly below the locks. This sewage is untreated and enters the river at numerous outlets on both sides of the boundary. Both cities have fairly complete sewer systems, but there are no interceptors along the waterfront.

The 1948 estimated combined population for the two principal municipalities is shown in table SM-3. Excluding rural and unsewered municipal areas, the contributing population is approximately 45,500.

TABLE SM-3—PRINCIPAL SOURCES OF DOMESTIC WASTES—LAKE SUPERIOR-LAKE HURON SECTION

Municipality	Receiving Stream	Population		Sewage Treatment
		Total (Est.) 1948	Served by Sewers	
Sault Ste. Marie, Ont.	St. Marys R.	29,700	28,200	None
Sault Ste. Marie, Mich.	St. Marys R.	17,300	17,300	None
Total		47,000	45,500	

The estimated volume of untreated sewage from these two municipalities is shown in table SM-4.

TABLE SM-4—VOLUME OF MUNICIPAL WASTES

Area	Volume—Gallons per Day	
	United States	Imperial
United States Side	3,500,000	2,910,000
Canadian Side	3,120,000	2,600,000
Total	6,620,000	5,510,000

Other sources of sewage pollution exist above and below the cities of Sault Ste. Marie. These include the unsewered portions of both cities and summer cottages and water front residences not connected to any public sewer system. In the upper river, on the Michigan side, there are private outfalls and a septic tank overflow from a State institution. On the Ontario side, summer resorts and waterfront residences contribute pollution. In the lower river several small hotels, encampments, and Pavignon Creek draining the Bayview area of Sault Ste. Marie, Ontario, discharge sewage to the river.

The disposal of garbage and other refuse in both cities is not a contributing factor to the pollution problem. On the Michigan side disposal is by dumping and burial at inland points. On the Ontario side incineration is employed in a municipally operated plant. No garbage has been used as fill material on river front lots.

Industrial Wastes

Sources of industrial waste pollution in the Lake Superior-Lake Huron section are concentrated in that part of the river extending from about one-half mile below the locks to 2½ miles upstream. The industries contributing wastes are as follows:

Canada:
- Dominion Tar & Chemical—Oils, phenols.
- Algoma Steel Corporation—Ammonium compounds, phenols, oils, cyanides, solids, iron, acids.
- Abitibi Power & Paper Company—Solids, B.O.D., sulphite, liquors.

United States:
- Northwestern Leather Company — Solids, B.O.D., phenols.
- Union Carbide and Carbon Corporation—Solids.

The summary of industrial wastes discharged into the St. Marys River is shown in table SM-5.

TABLE SM-5—SUMMARY OF INDUSTRIAL WASTES DISCHARGES

	Quantity Discharged Daily		
	Canada	United States	Total
Wastes:			
MGD (U. S.)	146	2.4	148.4
MGD (Imp.)	122	2.0	124.0
Phenols—Pounds	280	0	280
Ammonium Compounds—Pounds	3,500	0	3,500
Cyanides—Pounds	3,170	0	3,170
Oils—Gals. (U. S.)	1,020	0	1,020
Gals. (Imp.)	850	0	850
B.O.D.—Pounds	217,900	7,800	225,700
Pop. Equiv.—Persons	1,282,000	46,000	1,328,000
Suspended Solids—Pounds	75,000	4,800	79,800

On the Canadian side, phenols result from coking operations at the steel company's plant and from the by-products tar plant associated with it. An unknown amount is discharged on the United States side above the locks in the vicinity of the Northwestern Leather Company's outfall. Approximately 96 percent of the 280 pounds of phenol discharged daily on the Canadian side enters the river below the locks. The balance is discharged intermittently and adversely affects the quality of the Sault Ste. Marie, Ontario water supply. There is also a possibility of accidental spillage of oils and phenols. The steel plant discharges ammonium compounds at a computed amount of 3,500 pounds a day. Cyanides from this same source, in the coking operations, are computed at 3,170 pounds per day. Oils discharged amount to 850 Imperial gallons per day, and are carried in the steel corporation's trunk sewer discharging below the locks. The biochemical oxygen demand of the industrial wastes amounted to 225,700 pounds daily, having a population equivalent of 1,328,000 persons. The suspended solids in the industrial wastes reached the high figure of 79,800 pounds daily, consisting largely of iron dust and paper fibre.

Wastes from Navigation

The character of wastes contributed to boundary waters from vessels has been discussed at length in chapter VII of the Lake Huron-Lake Erie section report. The pollution from this source is equally significant in the St. Marys River. The estimated wastes from vessels in this section are 30,000 U. S. (25,000 Imp.) gallons per day, or an average population of 1,000 persons, and 500 pounds of garbage. Bilge and ballast waters also are factors in the pollution of these waters.

Chapter SM-VII

POLLUTION EFFECTS ON BOUNDARY WATER QUALITY

Evaluation of the quality of the waters of the St. Marys River was made from the examination of water samples collected from representative sampling points above and below the major sources of pollution. In addition to the bacteriological and chemical analyses, a special study was made of river bottom deposits and floating debris for the purpose of judging the distribution of industrial wastes originating on both sides of the river.

Field studies were carried on during the summer and fall of 1947 and the spring of 1948, during which time a total of 2,495 bacteriological and 10,866 chemical determinations were made in laboratories established for this purpose in both cities. The laboratory examinations used were similar to those employed in the Lake Huron-Lake Erie section. An explanation of these tests is given in detail in chapter VIII of that report.

Analytical Results of the 1913 Investigation

In the 1913 investigation pollution was attributed largely to the discharge of domestic sewage from municipalities and vessels. Little cognizance was taken of industrial wastes, which have since assumed much greater importance. Thus the problem encountered in the earlier investigation is not entirely comparable with that of the present.

The St. Marys River at that time was considered by the sanitary experts to be of dangerous bacterial quality and unfit for use as a municipal water supply without adequate treatment. The extent of pollution in the upper St. Marys River was measured at 3 sampling ranges located above the water works intake of Sault Ste. Marie, Michigan. The first sampling range extended from Gros Cap to a point above Bay Mills. Pollution was most marked in the ship channel, with average numbers of B. coli per 100 c.c. ranging between 11 and 13. This was attributed to boat traffic since sampling points midway between the ship channel and the shore indicated B. coli values of less than 3 per 100 c.c.

The second range was located between Brush Point, on the United States side, and Point aux Pins, on the Canadian side. Average B. coli ranged from 13 to 22, being fairly evenly distributed throughout this narrow cross section.

The third range, located just above the intake at the Sault Ste. Marie, Michigan, water works, showed practically the same degree of pollution as at the previous range.

Samples taken from cross sections below the municipal outfalls showed gross pollution which extended, practically undiminished, to Neebish Island. Below this point the degree of pollution showed a marked decrease, with isolated B. coli counts up to 20 per 100 c.c. near shore points, but the general numbers varied from 0 to 4. In the narrows at Detour Passage low values of 0 to 4 were obtained, with an occasional count as high as 20.

The maximum B. coli values were found immediately below the two municipalities of Sault Ste. Marie, where counts as high as 640 occurred near the Canadian shore, 340 at United States shore points. Both the east and west channels at the head of Sugar Island showed B. coli from 200 to 400 per 100 c.c., whereas values at the lower end of the island varied from 25 to 250. The pollution was general throughout the river in both channels.

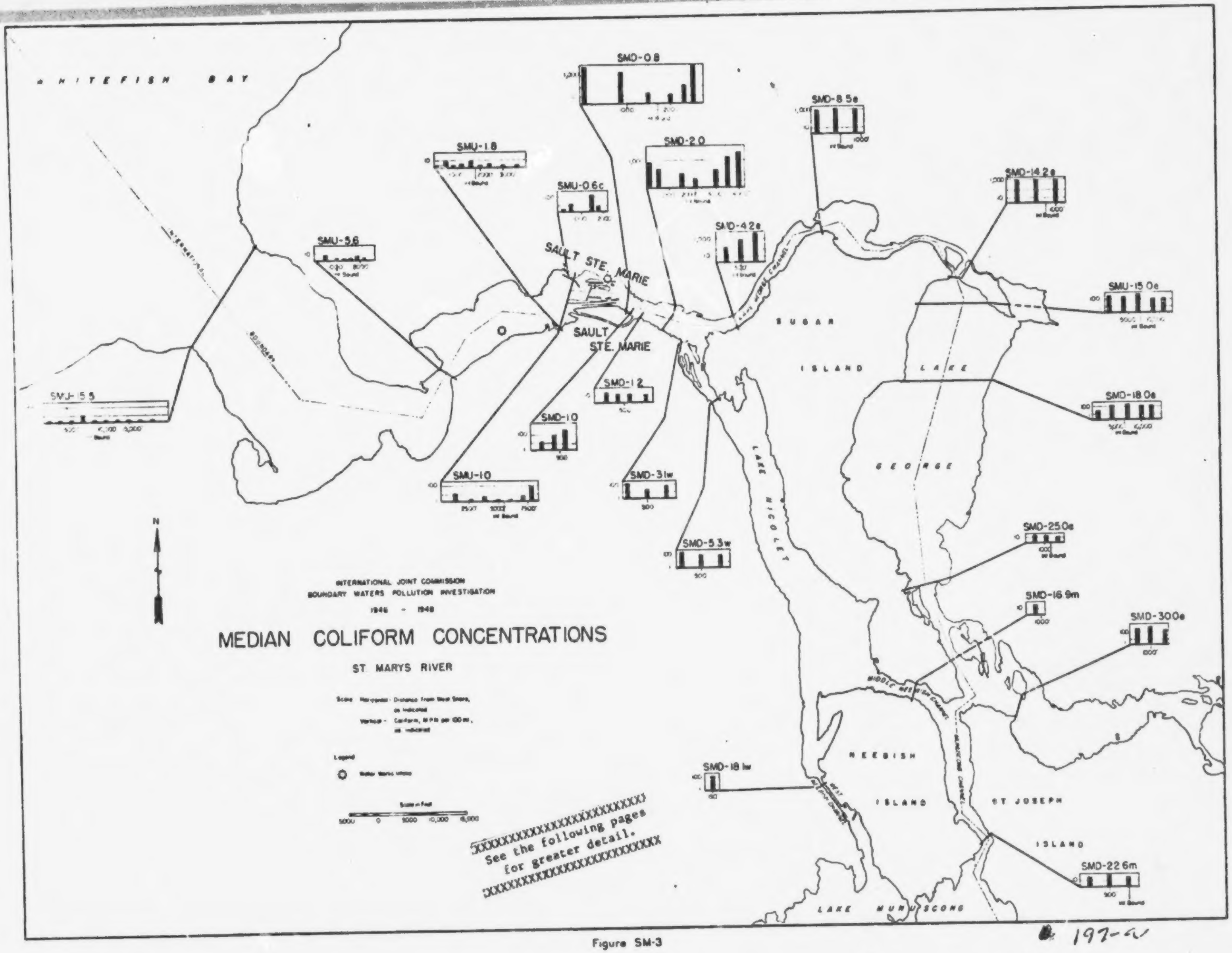
The fact that pollution was found to be common to both channels may be regarded as significant in respect to transboundary movement.

The bacteriological results as discussed above are given in terms of the Phelps Index. To convert to the Most Probable Number (M.P.N.) system, as used during the 1946-1948 investigation, the Phelps Index number should be multiplied by 2.4.

Analytical Results of the 1946-1948 Investigation

A summary of the analytical results of samples taken during the present investigation is presented in table SM-6 (see pages 198 to 207). The table includes the median bacterial values as well as the average chemical and physical figures. Maximum and minimum values and the number of samples taken at each sampling point are also shown. The coliform and phenol results are shown in figures SM-3 and SM-4 (follow page 196).

In the upper St. Marys River four principal sampling ranges were established, two of which were at approximately the same locations as used in 1913. The first of these, range SMU-15.5, was located at Whitefish Bay, from Gros Cap to Point Iroquois. The median M.P.N. coliform index per 100 ml. was generally less than 2.3, with a


WHITEFISH BAY
INTERNATIONAL
BOUNDARY
SAULT STE. MARIE
SAULT STE. MARIE
SUGAR ISLAND
LAKE GEORGE
LAKE NICOLET
NEEBISH ISLAND
ST JOSEPH ISLAND
LAKE MUNUSCONG
MIDDLE NEEBISH CHANNEL
WEST NEEBISH CHANNEL
BRUCE CHANNEL
N
SMU-15.5
SMU-5.6
SMU-1.8
SMU-0.6c
SMU-1.0
SMD-0.8
SMD-1.0
SMD-1.2
SMD-2.0
SMD-3.1w
SMD-4.2e
SMD-5.3w
SMD-8.5e
SMD-14.2e
SMU-15.0e
SMD-18.0e
SMD-18.1w
SMD-16.9m
SMD-25.0e
SMD-30.0e
SMD-22.6m

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948

MEDIAN COLIFORM CONCENTRATIONS

ST MARYS RIVER

Scale Horizontal - Distance from West Shore, as indicated
Vertical - Coliform, M.P.N. per 100 ml., as indicated

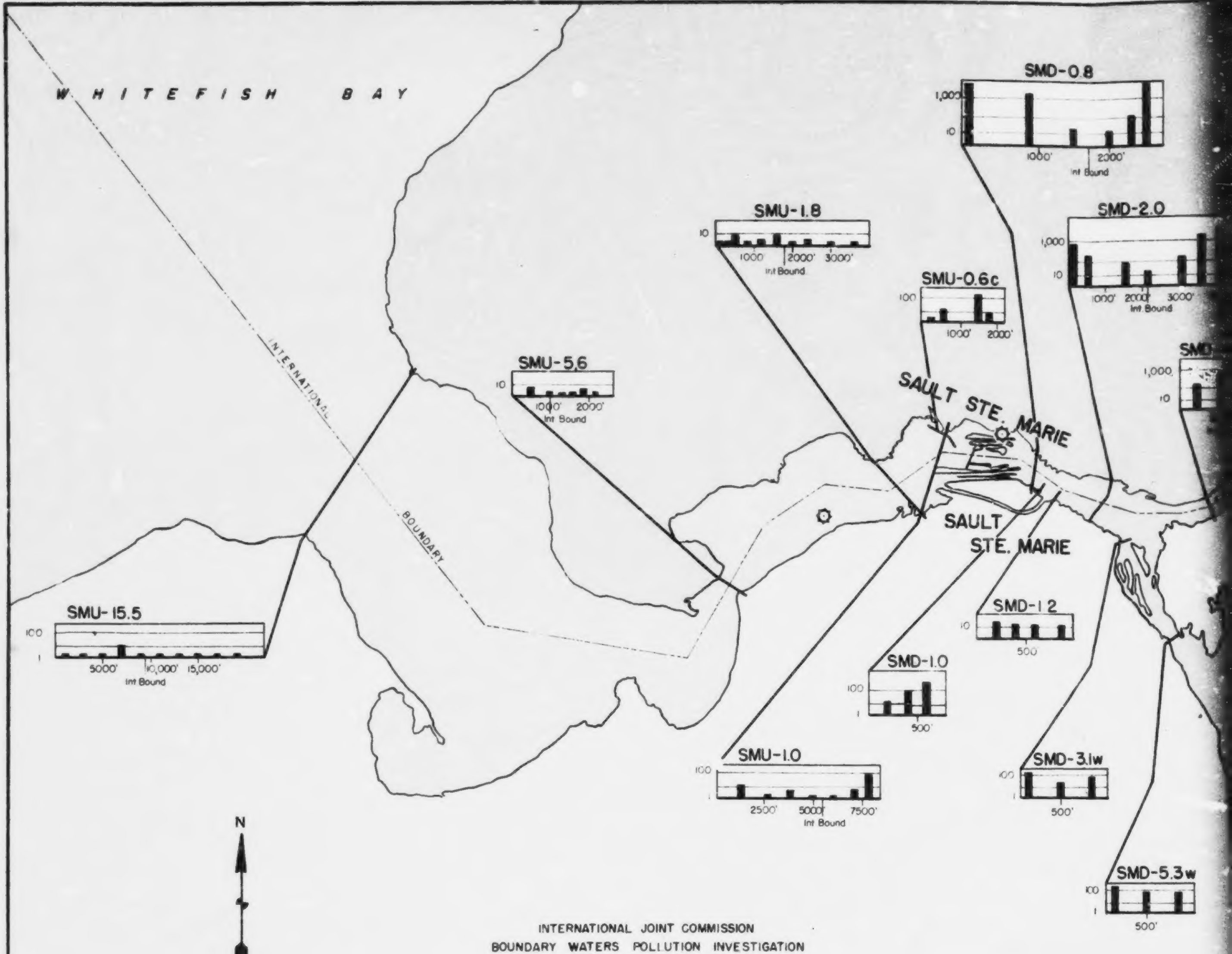
Legend
○ Water Works Intake

Scale in Feet
5000 0 5000 10,000 15,000

XXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXX

Figure SM-3

197-a


WHITEFISH BAY
INTERNATIONAL BOUNDARY
SAULT STE. MARIE
SAULT STE. MARIE
SMD-0.8
1,000
10
1000'
2000'
Int Bound
SMU-1.8
10
1000
2000'
3000'
Int Bound
SMD-2.0
1,000
10
1000'
2000'
3000'
Int Bound
SMU-0.6c
100
1000'
2000'
SMU-5.6
10
1000'
2000'
Int Bound
1,000
10
SMU-15.5
100
1
5000'
10,000'
15,000'
Int Bound
SMD-1.2
10
500'
SMD-1.0
100
1
500'
SMU-1.0
100
1
2500'
5000'
7500'
Int Bound
SMD-3.1w
100
1
500'
SMD-5.3w
100
1
500'
SMD-18.1w
100
1
150'
N

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948

MEDIAN COLIFORM CONCENTRATIONS

ST. MARYS RIVER

Scale Horizontal - Distance from West Shore, as Indicated
Vertical - Coliform, MPN per 100 ml, as indicated

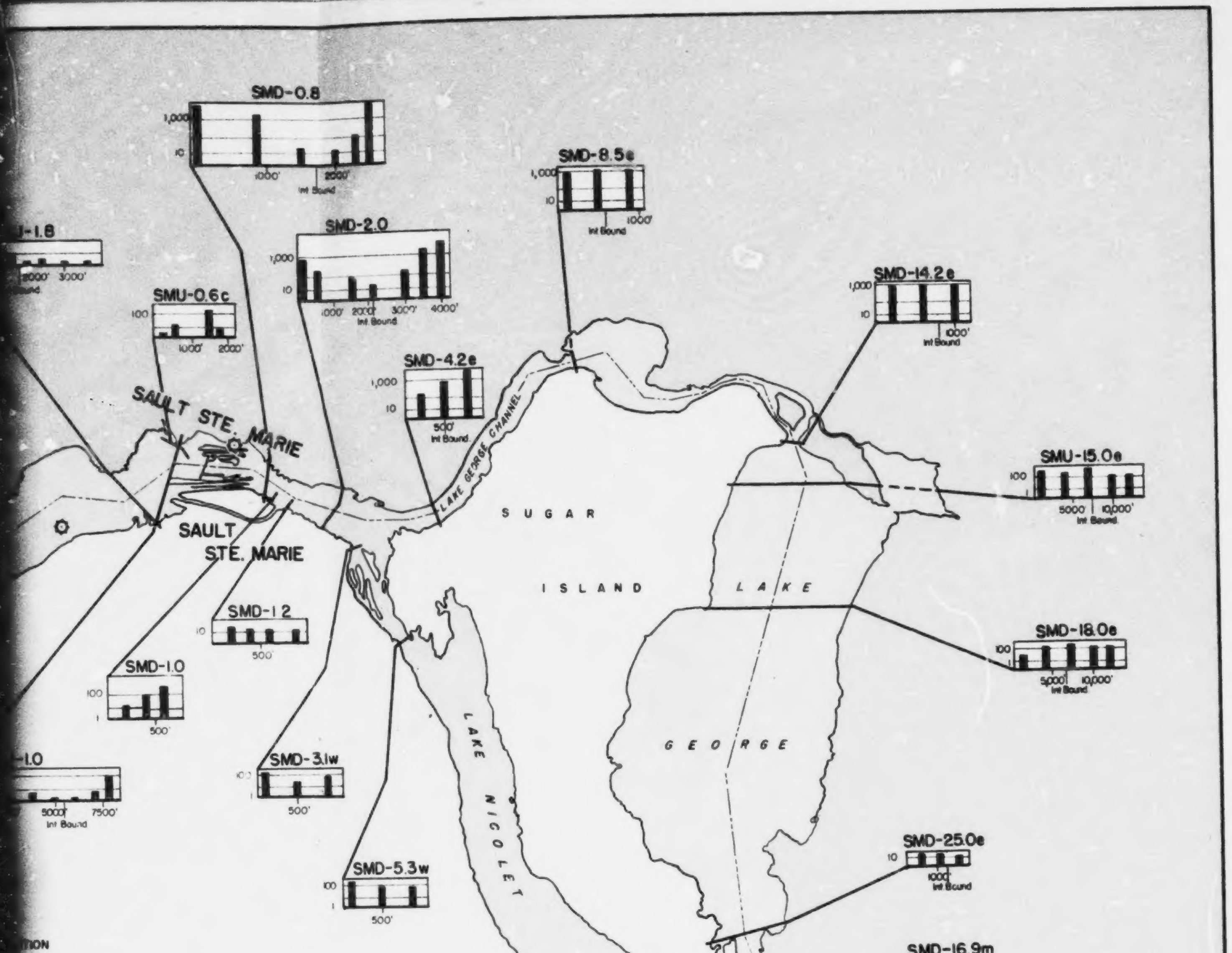
Legend

⊙ Water Works Intake

Scale in Feet

5000 0 5000 10,000 15,000

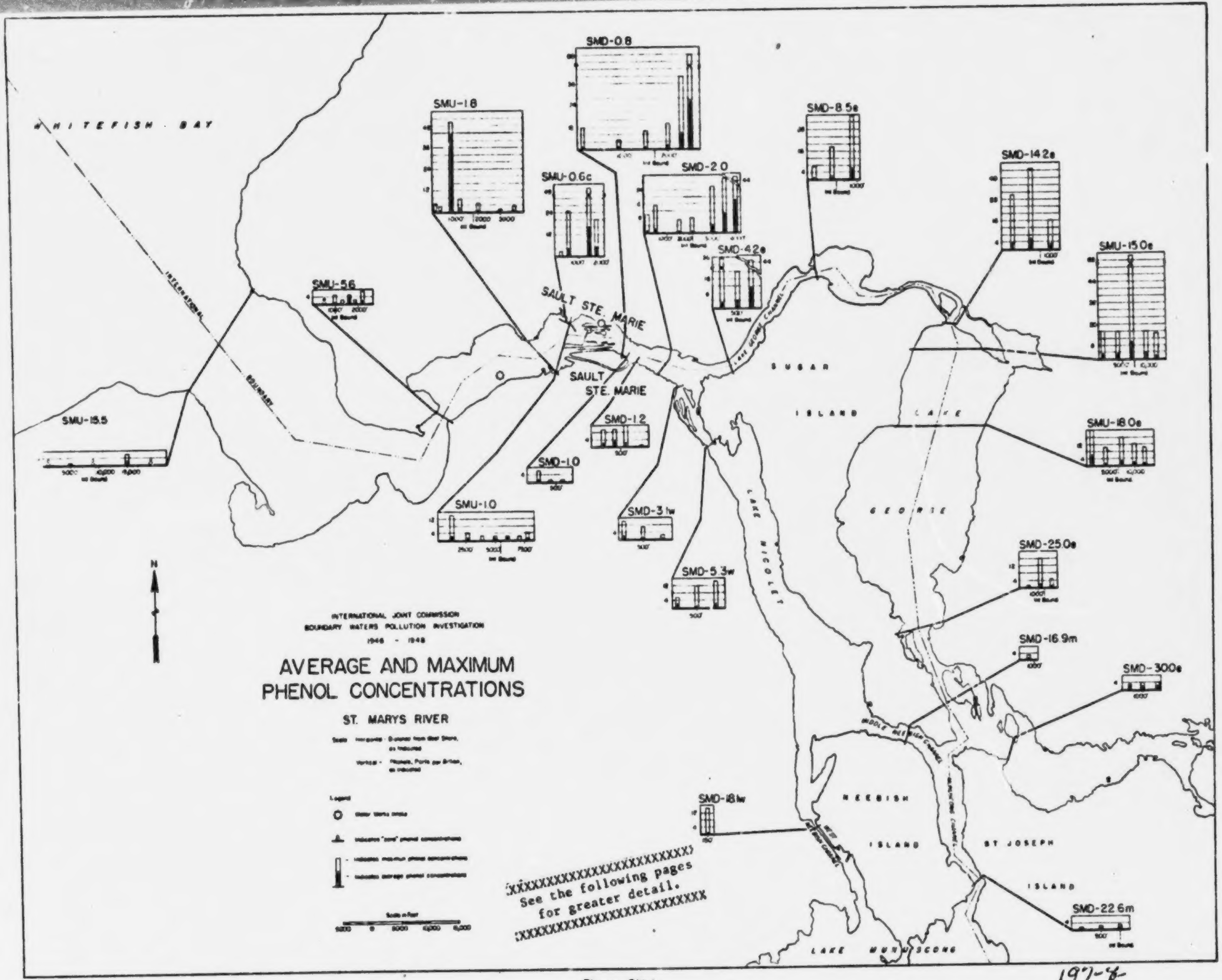
Figure SM-3



SMD-0.8
1,000
10
1000'
2000'
Int Bound
SMD-8.5e
1,000
10
1000'
Int Bound
I-1.8
2000'
3000'
Bound
SMD-2.0
1,000
10
1000'
2000'
3000'
4000'
Int Bound
SMD-14.2e
1,000
10
1000'
Int Bound
SMU-0.6c
100
1000'
2000'
SMD-4.2e
1,000
10
500'
Int Bound
SAULT STE. MARIE
LAKE GEORGE CHANNEL
SMU-15.0e
100
1
5000
10,000'
Int Bound
SAULT
STE. MARIE
SUGAR
ISLAND
LAKE
SMD-1.2
10
500'
SMD-18.0e
100
1
5,000
10,000'
Int Bound
SMD-1.0
100
1
500'
GEORGE
LAKE NICOLET
I-1.0
5000'
7500'
Int Bound
SMD-3.1w
100
1
500'
SMD-25.0e
10
1000'
Int Bound
SMD-5.3w
100
1
500'
TION
SMD-16.9m
10
1000'
CENTRATIONS
SMD-30.0e
100
1
1000'
MIDDLE NEEBISH CHANNEL
NEEBISH
MUNUSCONG CHANNEL
SMD-18.1w
100
1
150'
WEST NEEBISH CHANNEL
ISLAND
ST. JOSEPH
ISLAND
SMD-22.6m
10
500'
Int Bound
LAKE MUNUSCONG

Figure SM-3

197-a


WHITEFISH BAY
INTERNATIONAL BOUNDARY
SMU-15.5
SMU-5.6
SMU-1.8
SMU-0.6c
SMU-1.0
SMD-0.8
SMD-1.0
SMD-1.2
SMD-2.0
SMD-3.1w
SMD-4.2e
SMD-5.3w
SMD-8.5e
SMD-14.2e
SMU-15.0e
SMU-18.0e
SMD-25.0e
SMD-16.9m
SMD-30.0e
SMD-18.1w
SMD-22.6m
SAULT STE. MARIE
SAULT STE. MARIE
SUGAR ISLAND
LAKE GEORGE
LAKE NICOLET
NEEBISH ISLAND
ST JOSEPH ISLAND
LAKE MUNUSCONG
N
Scale: Horizontal - Distance from West Shore, as indicated
Vertical - Phenols, Parts per Billion, as indicated
Legend
Water Works Intake
Indicates "zero" phenol concentrations
Indicates maximum phenol concentrations
Indicates average phenol concentrations
Scale in Feet
5000 0 5000 10,000 15,000

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948

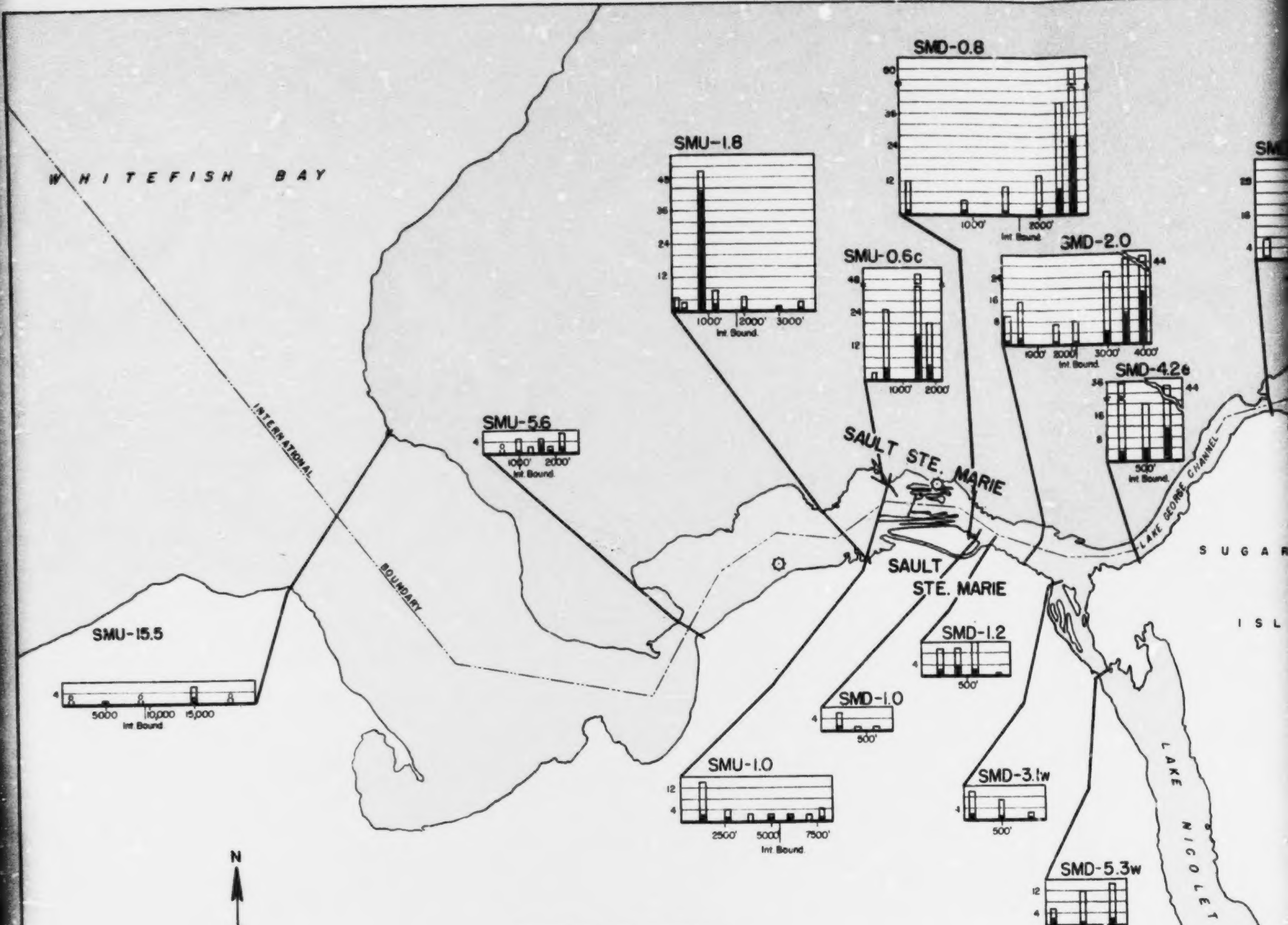
AVERAGE AND MAXIMUM PHENOL CONCENTRATIONS

ST. MARYS RIVER

XXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXX

Figure SM-4

197-8


WHITEFISH BAY
INTERNATIONAL
BOUNDARY
SMU-15.5
5000
10,000
15,000
Int Bound
SMU-5.6
1000'
2000'
Int. Bound.
SMU-1.8
48
36
24
12
1000'
2000'
3000'
Int. Bound.
SMU-0.6c
48
24
12
1000'
2000'
SMD-0.8
60
36
24
12
1000'
2000'
Int. Bound.
SMD-2.0
24
16
8
44
1000'
2000'
3000'
4000'
Int. Bound.
SMD-4.26
36
16
8
44
500'
Int. Bound.
SAULT STE. MARIE
SAULT
STE. MARIE
LAKE GEORGE CHANNEL
SUGAR
ISL
SMD-1.2
4
500'
SMD-1.0
4
500'
SMU-1.0
12
4
2500'
5000'
7500'
Int. Bound.
SMD-3.1w
4
500'
SMD-5.3w
12
4
500'
LAKE NICOLET
SMD-18.1w
12
4
150'
NEEBISH CH
N

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948

AVERAGE AND MAXIMUM PHENOL CONCENTRATIONS

ST. MARYS RIVER

Scale Horizontal - Distance from West Shore, as Indicated

Vertical - Phenols, Parts per Billion, as indicated

Legend

⚙ Water Works Intake

8 Indicates "zero" phenol concentrations

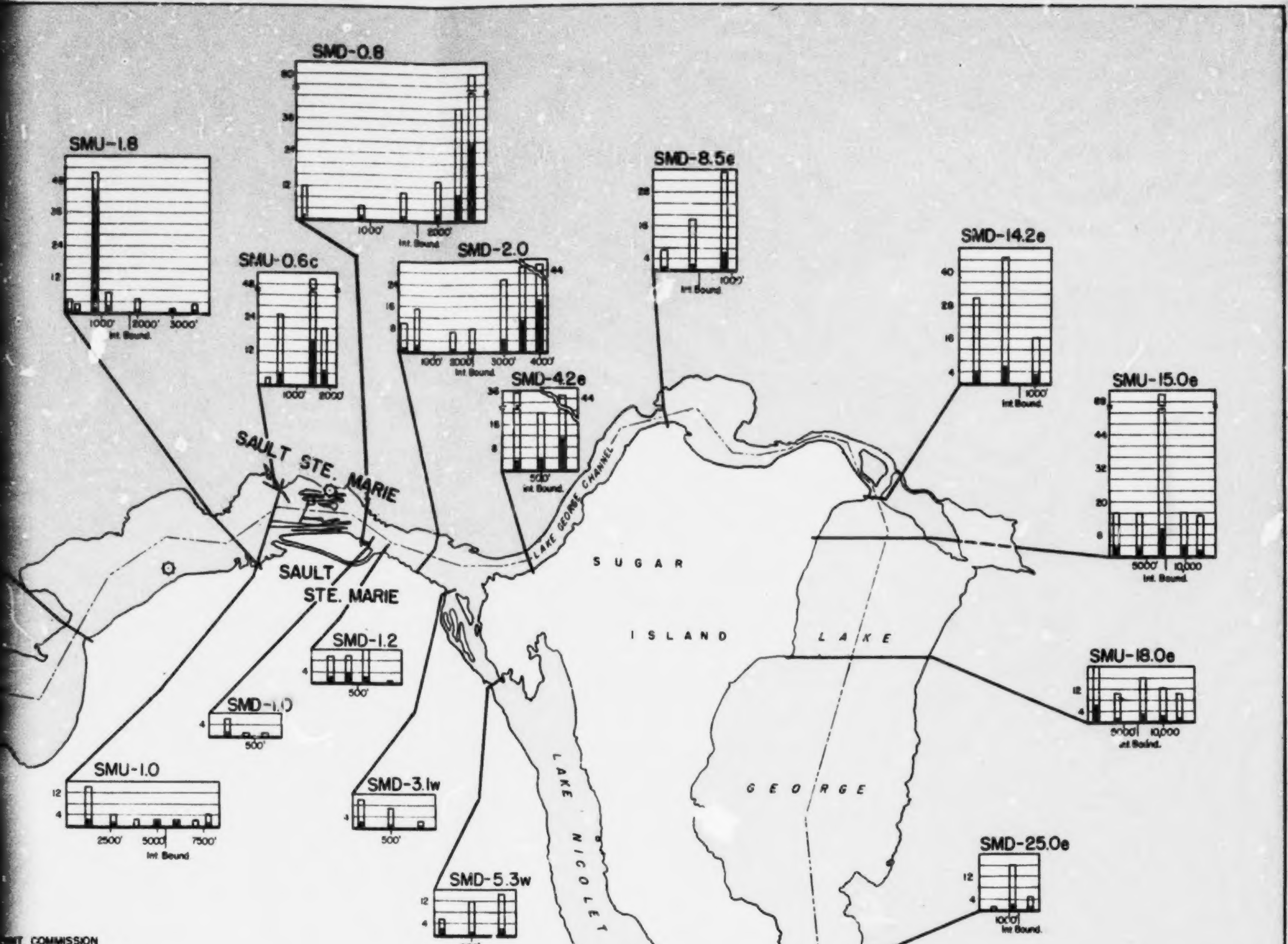
▯ - Indicates maximum phenol concentrations

▮ - Indicates average phenol concentrations

Scale in Feet

5000 0 5000 10,000 15,000

Figure SM-4



SMU-1.8
SMD-0.8
SMU-0.6c
SMD-2.0
SMD-8.5e
SMD-14.2e
SMD-4.2e
SMU-15.0e
SAULT STE. MARIE
SAULT
STE. MARIE
LAKE GEORGE CHANNEL
SUGAR
ISLAND
LAKE
GEORGE
SMD-1.2
SMD-1.0
SMU-18.0e
SMU-1.0
SMD-3.1w
SMD-5.3w
LAKE NICOLET
SMD-25.0e
SMD-16.9m
SMD-30.0e
MIDDLE NEEBISH CHANNEL
MUNUSCONG CHANNEL
SMD-18.1w
WEST NEEBISH CHANNEL
NEEBISH
ISLAND
ST JOSEPH
ISLAND
SMD-22.6m
LAKE MUNUSCONG
Int. Bound.
1000'
2000'
3000'
4000'
500'
150'
2500'
5000'
7500'
10,000
...INT COMMISSION
...LUTION INVESTIGATION
...1948
...D MAXIMUM
...ENTRATIONS
... RIVER
...from West Shore,
...ducted
...s, Parts per Billion,
...ducted
...nol concentrations
...phenol concentrations
...phenol concentrations
10,000
15,000

Figure SM-4

197-8

high median of 12 close to the International Boundary and the navigation channel.

The second range, SMU-5.6, located in the narrows between Brush Point and Point aux Pins, showed median M.P.N. values between 3.6 and 7.8, indicating a slight increase over the previous range. In one case the maximum M.P.N. value reached 350 at a point 500 feet from the United States shore.

The third and fourth ranges, SMU-1.8 and SMU-1.0, located in Ashmun Bay, start below the Northwestern Leather Company and run to Old Vessel Point and the Algoma Steel Corporation dock, respectively, on the Canadian shore. Coliform results in midstream ranged from less than 1 to a median value of 9.1. Median shore values increased in the vicinity of industrial outlets. On the United States shore the median and maximum M.P.N. values were 17 and 350, respectively. At the Canadian end of range SMU-1.0 the median and maximum values were 94 and 920, respectively. One sampling point in the polluted back eddy above the Algoma Steel Corporation's boat slip showed median and maximum M.P.N. values of 230 and 4,600, respectively.

Some high M.P.N. values were found in a series of short sampling ranges near the Northwestern Leather Company's outfalls. Although a maximum M.P.N. of 11,000 occurred at the No. 2 outfall, no such concentration was found in the samples of range SMU-1.0, a short distance below.

In the lower St. Marys River a much higher degree of bacterial pollution exists, due to the discharge of domestic and industrial wastes. Pollution from the many municipal outfalls on both sides tends to hug the shores to a point where the river divides at Sugar Island. This is illustrated by median coliform values which ranged from 930 to 4,600 on the United States side, from 23 to 43 in midstream, and from 4,600 to 5,400 on the Canadian side. At the head of Sugar Island on range SMD 3-1W, M.P.N. values in the west or Lake Nicolet Channel varied from 220 near shore to 93 near the island. In the east or Lake George Channel, at range SMD-4.2e, values ranged from 3,500 at the Canadian shore to 280 at Sugar Island. Beyond this range the Lake George Channel narrows and is turbulent, causing a mixing and uniform distribution of the bacterial load across the stream. This uniform distribution of coliform values persisted at the same magnitude as far as the entrance to Lake George, at range SMD-14.2e, showing a median value of 930 per 100 ml. Through Lake George, a distance of 11 miles, there is a gradual reduction in numbers until at the outlet (range SMD-25.0e) the median values varied from 13 to 23.

A similar trend was observed in the Lake Nicolet Channel, where uniform distribution and reduction in M.P.N. values occurred. Median values of 300 near the mainland and 93 at midstream and at the Sugar Island shore were found at the entrance to Lake Nicolet, on range SMD-5.3w. M.P.N. values were found to be 150 in the West Neebish Channel and 79 in the Middle Neebish Channel, on ranges SMD-18.1w and SMD-16.9m, respectively. A comparable value was found in the shipping lane of the international or Munuscong Channel, between Neebish Island and St. Joseph Island.

Bacteriological samples taken in the Canadian waters between St. Joseph Island and the mainland, at range SMD-30.0e, showed an increase in coliform values over those of the ranges immediately upstream. No reason is apparent for this rise in M.P.N. values from 23 to 460 in the centers of these channels.

Maximum coliform values, considerably higher than the medians, occurred throughout the whole area. Values as great as 110,000 were found below main sewer outfalls at Sault Ste. Marie, on the Canadian side and 92,000 on the United States side. The maximum values fell off rapidly with a high of 24,000 occurring at the head of Sugar Island and only 4,600 at the entrance to Lake George. The highest value at the lower end of Lake George was 930 as against a median of 23. The heavy concentration of bacterial pollution is carried down the Lake George Channel rather than the Lake Nicolet Channel.

A comparison of coliform results in the upper St. Marys River for the 1913 and 1946-1948 investigations reveals no substantial change. The figures for 1946-1948 are somewhat lower but the difference is not significant, and the bacterial quality continues to be normal for such surface waters. Whether this slight difference in pollution is due primarily to a reduction in passenger traffic is not clear.

In the lower river, below the municipal sewer outfalls at range SMD-2.0, the coliform pollution is now approximately twice as great as in 1913. In the Lake George Channel it continues at about this same ratio. In the Lake Nicolet Channel the present figures show a lower coliform value than in 1913. Similarly, at the farthest downstream ranges the coliform values are less now than they were in the previous investigation.

In the 1913 investigation the over-all increase in coliform pollution in this section was roughly 6 times. In the present investigation the increase is 33 times. Both of these increases are influenced by the effects of natural purification agencies. The increase in coliform values from above the locks to the range of maximum pollution today is

TABLE SM-6—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. MARYS RIVER

Sampling Point	Mileage Index No.	Feet from U. S. Shore		Coliforms M.P.N. per 100 ml.	Phenols ppb	Chlorides ppm	pH	Alkalinity ppm	Turbidity ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm
Point Iroquois, Mich., across to Gros Cap, Ont. (at Head of St. Marys River near Whitefish Bay).	SMU-15.5	1,000	Median	<1.8	......	......	......	......	......	......	......	......
			Average	......	0	2.8	7.9	44	0.7	13.0	10.5	0.93
			Maximum	2.3	0	5.2	8.0	48	1.2	18.0	13.3	3.50
			Minimum	1.8	0	2.1	7.6	40	0.4	5.5	9.2	0.20
			No. of Samples	15	3	9	9	9	7	5	10	8
		3,000	Median	<2.3	......	......	......	......	......	......	......	......
			Average	......	......	2.2	7.5	45	......	16.0	10.2	0.36
			Maximum	<2.3	......	2.2	7.6	47	......	17.0	10.5	0.53
			Minimum	<2.3	......	2.2	7.4	43	......	15.0	9.9	0.20
			No. of Samples	2	......	2	2	2	......	2	2	2
		5,000	Median	<1.8	......	......	......	......	......	......	......	......
			Average	......	1	2.1	7.7	45	......	16.0	10.4	0.43
			Maximum	<2.3	1	2.1	7.7	45	......	17.0	10.4	0.46
			Minimum	<1.8	0	2.0	7.7	44	......	15.0	10.3	0.40
			No. of Samples	5	3	2	2	2	......	2	2	2
		7,000	Median	12	......	......	......	......	......	......	......	......
			Average	......	......	2.1	7.7	45	......	15.5	10.4	0.40
			Maximum	23	......	2.3	7.7	46	......	16.0	10.4	0.40
			Minimum	<2.3	......	1.9	7.7	44	....	15.0	10.4	0.40
			No. of Samples	2	......	2	2	2	......	2	2	1
		9,000	Median	1.8	......	......	......	......	......	......	......	......
			Average	......	0	2.3	7.8	42	0.9	12.0	11.6	0.97
			Maximum	3.6	0	3.0	7.9	46	1.5	16.5	13.3	3.10
			Minimum	<1.8	0	2.0	7.7	40	0.4	5.0	10.4	0.30
			No. of Samples	5	3	5	5	5	3	5	5	5
		9,500			International Boundary							
		11,000	Median	<1.8	......	......	......	......	......	......	......	......
			Average	......	......	3.6	7.8	45	0.5	16.0	9.9	0.47
			Maximum	22	......	7.0	8.0	46	1.2	17.0	10.7	0.83
			Minimum	<1.8	......	1.9	7.6	44	0.2	15.0	9.2	0.00
			No. of Samples	11	......	7	8	7	5	2	7	5
		13,000	Median	<2.3	......	......	......	......	......	......	......	......
			Average	......	......	2.1	7.7	45	......	16.0	10.4	0.52
			Maximum	<2.3	......	2.2	7.7	46	......	17.0	10.5	0.58
			Minimum	<2.3	......	2.0	7.6	44	......	15.0	10.3	0.46
			No. of Samples	2	......	2	2	2	......	2	2	2
		15,000	Median	<1.8	......	......	......	......	......	......	......	......
			Average	......	2	2.1	7.7	45	......	16.0	10.5	0.50
			Maximum	<2.3	6	2.1	7.7	45	......	17.0	10.5	0.57
			Minimum	<1.8	0	2.1	7.6	44	......	15.0	10.4	0.44
			No. of Samples	5	3	2	2	2	......	2	2	2
		17,000	Median	<2.3	......	......	......	......	......	......	......	......
			Average	......	......	2.1	7.7	45	......	16.0	10.3	0.44
			Maximum	<2.3	......	2.1	7.7	46	......	17.0	10.4	0.48
			Minimum	<2.3	......	2.1	7.7	44	......	15.0	10.2	0.39
			No. of Samples	2	......	2	2	2	......	2	2	2
		19,000	Median	<1.8		......	......	......	......	......	......	......
			Average	......	0	3.0	7.8	43	0.6	11.3	10.9	0.73
			Maximum	33	0	6.9	7.9	46	1.2	17.0	13.3	2.85
			Minimum	<1.8	0	2.1	7.6	40	0.3	5.0	9.8	0.20
			No. of Samples	14	4	9	9	8	7	5	11	8
		20,000			Canadian Shore							
Upper St. Marys River Brush Point Aux Pins (near USCG No. 6 Lookout Station).	SMU-5.6	500	Median	7.8	......	......	......	......	......	......	......	......
			Average	......	0	4.2	7.8	45	2.6	......	9.5	0.5
			Maximum	350	0	6.8	8.2	48	4.0	......	10.0	0.8
			Minimum	<1.8	0	1.7	7.6	44	1.1	......	9.2	0.2
			No. of Samples	13	2	10	11	7	9	......	8	8
		1,000			International Boundary							

TABLE SM-6—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. MARYS RIVER—Continued

Sampling Point	Mileage Index No.	Feet from U. S. Shore		Coliforms M.P.N. per 100 ml.	Phenols ppb	Chlorides ppm	pH	Alkalinity ppm	Turbidity ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm
Upper St. Marys River Brush Point Aux Pins (near USCG No. 6 Lookout Station) (Continued).	SMU-5.6	1,000	Median	3.6								
			Average		1	2.0	7.6	44	3.3	15.0	10.3	0.53
			Maximum	43	5	2.3	7.8	46	5.0	18.5	11.9	1.3
			Minimum	3.6	0	1.7	7.4	36	2.3	10.0	9.3	0.21
			No. of Samples	15	4	14	13	14	7	14	14	14
		1,300	Median	2								
			Average		0	4.0	7.8	45	0.78	17.5	9.8	0.58
			Maximum	350	2	7.0	8.0	48	1.2	18.5	10.2	1.67
			Minimum	<1.8	0	2.1	7.6	42	0.4	16.0	9.5	0.2
			No. of Samples	23	8	14	16	13	10	5	13	13
		1,600	Median	3.6								
			Average		3	2.1	7.6	44	3.7	13.6	10.8	0.81
			Maximum	75	5	2.5	7.8	48	10.0	18.0	13.1	2.40
			Minimum	<2.3	0	1.6	7.3	36	2.2	8.0	9.8	0.80
			No. of Samples	15	5	16	15	16	9	16	16	16
		1,900	Median	6.8								
			Average		1	3.3	7.8	43	0.8	13.0	10.8	0.84
			Maximum	170	2	6.9	8.4	48	1.3	17.5	13.4	3.00
			Minimum	<1.8	0	0.5	7.6	40	0.5	5.0	9.0	0.20
			No. of Samples	23	7	21	22	19	16	11	19	18
		2,200	Median	3.6								
			Average		2	2.0	7.6	44	3.3	13.5	10.8	0.66
			Maximum	43	7	2.3	7.8	46	6.1	17.5	13.0	1.80
			Minimum	<1.8	0	1.8	7.3	38	2.3	7.0	10.0	0.38
			No. of Samples	21	9	14	13	14	8	14	14	14
		2,500			Canadian Shore							
At Sault Ste. Marie, Mich., Water Intake near USCG Dispatch Station.	SMU-3.2	1,500	Median	<3.6								
			Average		3	1.2	7.5	44	3.3	11	11.0	0.6
			Maximum	9.1	15	2.8	7.7	46	8	15	12.6	1.6
			Minimum	3.0	0	1.2	7.3	36	1.0	5.0	9.9	0.31
			No. of Samples	16	12	16	14	16	16	16	15	15
Upstream from No. 1 Tannery Sewer Outlet.	SMU-2.32	100	Median	23								
			Average		1	2.9	7.7	46	3.0	14.0	10.5	0.60
			Maximum	1,100	5	7.0	7.9	50	4.0	19.0	11.1	14.0
			Minimum	<3.6	1	1.6	7.5	44	2.0	11.0	9.5	0.35
			No. of Samples	9	5	10	10	10	10	10	10	10
At No. 1 Tannery Sewer Outlet.	SMU-2.3	100	Median	430								
			Average		5	16	8.4	50	5.7	14.0	10.1	3.86
			Maximum	2,400	40	66	9.4	58	25.0	20.0	10.9	16.5
			Minimum	3.6	0	1.8	7.7	44	1.9	11.0	8.9	0.50
			No. of Samples	11	8	13	12	13	13	13	12	12
		200	Median	23								
			Average		1	4.4	7.7	45	2.5	12.0	10.9	0.79
			Maximum	43	1	7.9	7.9	46	3.2	13.0	11.0	1.45
			Minimum	<3.6	0	1.8	7.6	44	1.8	12.0	10.9	0.31
			No. of Samples	5	2	5	5	5	5	5	5	5
At No. 2 Tannery Outfall (300 feet downstream from No. 1 Outfall.	SMU-2.24	100	Median	460								
			Average		43	34	8.5	55	15	15.5	8.4	25.4
			Maximum	11,000	350	160	>9.6	85	62	20.0	10.7	20.5
			Minimum	<3.6	0	2.9	7.5	44	3.7	11.0	3.0	1.75
			No. of Samples	11	9	11	12	11	13	12	12	12
		200	Median	9.1								
			Average		2	16	8.2	48	4.8	13.0	10.6	2.11
			Maximum	240	7	38	9.1	60	11.0	15.0	10.9	4.8
			Minimum	<3.6	0	2.8	7.7	44	1.6	12.0	9.5	0.4
			No. of Samples	7	4	7	6	7	7	7	7	7
		400	Median	9.1								
			Average		0	3.7	7.7	45	2.8	12.0	10.9	0.75
			Maximum	<36	0	6.0	7.8	47	3.5	12.5	11.0	1.09
			Minimum	<3.6	0	1.8	7.5	44	1.7	12.0	10.8	0.45
			No. of Samples	6	2	5	5	5	5	5	5	5

TABLE SM-6—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. MARYS RIVER—Continued

Sampling Point	Mileage Index No.	Feet from U. S. Shore		Coliforms M.P.N. per 100 ml.	Phenols ppb	Chlorides ppm	pH	Alkalinity ppm	Turbidity ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm
Below Tannery Outlets.	SMU-2.1	100	Median	330	......	......	......	......	......	......	......	......
			Average	......	25	59	8.4	59	15.0	13.0	9.5	9.8
			Maximum	4,600	80	250	>9.6	100	40.0	15.0	10.7	37.7
			Minimum	23	0	1.7	7.6	44	2.0	12.0	6.5	0.6
			No. of Samples	6	4	7	6	7	7	7	6	6
		200	Median	21	......	......	......	......	......	......	......	......
			Average	......	1	14	8.1	48	5.2	13.0	10.4	2.62
			Maximum	39	1	37	9.5	62	10	14.0	10.8	6.5
			Minimum	3.0	0	1.5	7.7	44	1.6	12.0	9.3	0.4
			No. of Samples	6	3	6	5	6	6	6	6	6
	SMU-2.0	100	Median	430	......	......	......	......	......	......	......	......
			Average	......	15	38	8.5	54	15.6	13.0	9.4	8.6
			Maximum	2,400	40	85	9.5	66	42.0	15.0	10.6	28.2
			Minimum	23	0	3.0	7.7	47	1.6	11.5	7.2	0.8
			No. of Samples	6	4	7	6	7	7	7	6	6
		200	Median	25	......	......	......	......	......	......	......	......
			Average	......	1	19.7	8.3	49	4.9	13.5	10.5	2.44
			Maximum	390	1	48	8.7	55	8.0	14.0	10.9	7.50
			Minimum	3.0	0	1.6	7.8	43	2.2	12.0	10.9	0.6
			No. of Samples	6	3	6	5	6	6	6	6	6
Below Tannery Outlets across to N. W. Coal Dock.	SMU-1.9	100	Median	330	......	......	......	......	......	......	......	......
			Average	......	49	34	8.3	51	6.5	12.5	9.7	4.3
			Maximum	4,600	100	74	8.8	62	17	14.0	10.4	7.35
			Minimum	15	0	1.8	8.0	45	1.5	11.5	8.7	6.3
			No. of Samples	6	4	7	5	7	7	7	6	6
		200	Median	93	......	......	......	......	......	......	......	......
			Average	......	28	24	8.3	53	5.1	12.5	9.8	4.39
			Maximum	2,400	80	37	9.3	57	8.0	14.0	10.8	11.6
			Minimum	9.1	5	1.7	7.9	48	1.5	11.5	7.8	0.8
			No. of Samples	6	3	6	5	6	5	6	6	6
		500	Median	170	......	......	......	......	......	......	......	......
			Average	......	1	9.5	8.0	47	3.6	12.5	10.5	1.54
			Maximum	930	1	18	8.4	51	6.8	14.0	11.0	2.65
			Minimum	<3.6	0	1.9	7.8	45	1.6	11.5	9.8	0.5
			No. of Samples	6	3	6	5	6	6	6	6	6
		0			United States Shore							
Northwestern Coal Co. Dock across to Old Vessel Point, Canada (below Tannery).	SMU-1.8	100	Median	3.6	......	......	......	......	......	......	......	......
			Average	......	1	2.4	7.6	44	4.0	12.5	10.6	0.72
			Maximum	150	5	5.3	7.8	8	10.2	17.5	12.7	1.31
			Minimum	<2.3	0	1.5	7.5	38	2.0	8.0	9.7	0.35
			No. of Samples	19	7	15	15	15	11	19	14	14
		300	Median	3.6	......	......	......	......	......	......	......	......
			Average	......	1	2.1	7.6	45	3.8	13.0	10.6	0.61
			Maximum	75	3	2.7	7.8	46	7.4	16.5	12.3	1.0
			Minimum	<3.6	0	1.7	7.4	44	2.6	9.0	9.9	0.32
			No. of Samples	17	5	10	11	10	6	17	12	12
		500	Median	9.1	......	......	......	......	......	......	......	......
			Average	......	......	2.2	7.6	45	......	16.5	10.0	0.57
			Maximum	14	......	2.5	7.6	46	......	17.0	10.2	0.74
			Minimum	3.6	......	2.0	7.6	44	......	15.5	9.9	0.48
			No. of Samples	4	......	4	4	4	......	4	4	4
		800	Median	3.6	......	......	......	......	......	......	......	......
			Average	......	43	2.1	7.5	44	5.9	13.5	10.7	0.61
			Maximum	23	50	3.0	7.6	45	11.5	11.0	12.6	1.2
			Minimum	<3.6	0	1.2	7.4	36	2.6	8.0	9.9	0.21
			No. of Samples	13	4	6	9	6	3	13	10	10
		1,200	Median	5.4	......	......	......	......	......	......	......	......
			Average	......	2	2.0	7.6	45	3.6	13.5	10.5	0.60
			Maximum	11	7	2.4	7.8	46	8.2	17.0	12.6	1.10
			Minimum	<2.3	0	1.7	7.4	36	2.1	8.0	10.1	0.36
			No. of Samples	16	4	10	10	10	5	16	9	9

TABLE SM-6—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. MARYS RIVER—Continued

Sampling Point	Mileage Index No.	Feet from U. S. Shore		Coliforms M.P.N. per 100 ml.	Phenols ppb	Chlorides ppm	pH	Alkalinity ppm	Turbidity ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm
Northwestern Coal Co. Dock across to Old Vessel Point, Canada (below Tannery) (Continued).	SMU-1.8	1,600	Median	9.1	......	......	......	......	......	......	......	......
			Average	....	......	2.2	7.6	45	......	16.0	10.1	0.64
			Maximum	23	......	2.4	7.6	45	......	17.0	10.2	0.77
			Minimum	<2.3	......	2.0	7.6	44	......	15.5	10.1	0.55
			No. of Samples	4	......	4	4	4	......	4	4	4
		1,800			International Boundary							
		2,000	Median	3.6	......	......	......	......	......	......	......	......
			Average	....	1	2.1	7.5	44	3.7	13.0	10.8	0.60
			Maximum	14	5	2.6	7.6	46	6.3	17.0	13.0	1.3
			Minimum	<2.3	0	1.7	7.3	36	2.0	7.0	10.0	0.33
			No. of Samples	15	6	11	11	10	5	15	10	10
		2,400	Median	5.4	......	......	......	......	......	......	......	......
			Average	....	......	2.2	7.6	44	......	16.0	10.1	0.68
			Maximum	14	......	2.7	7.6	45	......	17.0	10.1	0.85
			Minimum	2.3	......	2.0	7.6	43	......	15.0	10.1	0.34
			No. of Samples	4	......	4	4	4	......	4	4	4
		3,000	Median	3.6	......	......	......	......	......	......	......	......
			Average	....	0.4	2.1	7.5	43	5.6	13.0	10.8	0.45
			Maximum	14	1	2.8	7.6	45	7.0	17.0	13.1	2.3
			Minimum	<3.6	0	1.1	7.4	37	4.2	7.0	10.0	0.30
			No. of Samples	15	5	7	9	7	2	15	10	10
		3,600	Median	3.6	......	......	......	......	......	......	......	......
			Average	....	1	2.0	7.5	44	3.1	13.0	10.9	0.62
			Maximum	9.1	3	2.6	7.6	46	7.0	17.0	12.9	1.1
			Minimum	<2.3	0	1.2	7.3	36	2.0	7.0	10.1	0.30
			No. of Samples	14	6	10	10	10	7	14	19	9
		4,700			Canadian Shore							
Upper St. Marys River immediately above Locks to Falls.	SMU-1.0	1,200	Median	17	......	......	......	......	......	......	......	......
			Average	....	2	5.3	7.9	43	1.1	9.5	10.8	1.07
			Maximum	350	15	13.6	8.4	48	3.2	13.5	13.4	2.60
			Minimum	<1.8	0	2.0	7.6	40	0.5	7.0	9.2	0.30
			No. of Samples	20	11	16	17	14	16	6	14	13
		2,600	Median	2	......	......	......	......	......	......	......	......
			Average	....	1	3.7	7.8	43	9.3	9.5	11.3	7.8
			Maximum	350	4	7.0	8.4	46	2.3	13.5	13.3	2.40
			Minimum	<1.8	0	2.5	7.5	40	0.5	6.0	9.4	0
			No. of Samples	20	11	12	13	12	13	6	10	11
		3,800	Median	6.1	......	......	......	......	......	......	......	......
			Average	....	0	4.6	7.9	45	7.6	......	9.6	0.4
			Maximum	170	2	7.8	8.0	48	1.4	......	10.2	0.8
			Minimum	<1.8	0	2.4	7.7	43	0.3	......	9.0	0.0
			No. of Samples	20	11	10	11	8	10	......	7	8
		5,000	Median	<1.8	......	......	......	......	......	......	......	......
			Average	....	1	2.7	7.9	41	0.8	9.3	12.5	1.02
			Maximum	2	2	3.0	8.5	41	1.0	13.5	13.4	2.35
			Minimum	1.8	0	2.5	7.8	40	0.5	6.0	11.3	0.10
			No. of Samples	6	6	6	6	6	6	6	6	6
		5,500			International Boundary							
		6,000	Median	<1.8	......	......	......	......	......	......	......	......
			Average	....	1	......	......	......	......	......	......	......
			Maximum	<1.8	2	......	......	......	......	......	......	......
			Minimum	<1.8	0	......	......	......	......	......	......	......
			No. of Samples	6	5	......	......	......	......	......	......	......
		7,200	Median	7.8	......	......	......	......	......	......	......	......
			Average	....	0	3.9	7.9	42	0.7	9.5	11.4	0.84
			Maximum	140	2	6.9	8.5	48	1.2	13.5	13.2	2.35
			Minimum	<1.8	0	2.5	7.8	40	0.3	7.0	9.6	0.15
			No. of Samples	19	10	10	11	9	11	6	10	10

TABLE SM-6—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. MARYS RIVER—Continued

Sampling Point	Mileage Index No.	Feet from U. S. Shore		Coliforms M.P.N. per 100 ml.	Phenols ppb	Chlorides ppm	pH	Alkalinity ppm	Turbidity ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm
Upper St. Marys River immediately above Locks to Falls (Continued).	SMU-1.0	7,900	Median	94	......	......	......	......	......	......	......	......
			Average	....	1	3.8	7.9	44	1.6	10.0	10.8	0.78
			Maximum	920	4	7.8	8.5	48	4.0	13.5	13.2	2.85
			Minimum	<1.8	0	2.5	7.6	40	0.5	7.0	9.2	0.05
			No. of Samples	20	11	16	17	12	16	6	14	14
		7,900			Canadian Shore (At Algoma Steel Mill Boat Slip)							
		0			Canadian Lock Approach Wall							
Head of Canadian Lock and across Algoma Steel Co. Boat Slip.	SMU-0.6c	300	Median	3.6	......	......	......	......	......	......	......	......
			Average	....	0	2.0	7.5	44	3.0	12.5	11.1	0.71
			Maximum	230	2	2.4	7.7	46	8.0	16.5	12.9	1.4
			Minimum	<3.6	0	1.2	7.4	37	1.5	6.0	9.9	0.39
			No. of Samples	15	8	15	13	15	12	15	15	15
		600	Median	23	......	......	......	......	......	......	......	......
			Average	....	4	1.9	7.5	44	3.6	12.5	11.0	0.79
			Maximum	93	25	2.4	7.7	46	8.5	17.0	13.0	2.0
			Minimum	<2.3	0	1.4	7.3	37	2.2	6.0	10.0	0.43
			No. of Samples	15	7	14	12	14	10	15	15	15
		1,500	Median	230	......	......	......	......	......	......	......	......
			Average	....	16	2.0	7.5	46	5.8	13.5	10.4	1.04
			Maximum	4,600	50	2.5	7.7	51	18	18.0	12.4	2.2
			Minimum	23	0	1.6	7.3	37	1.8	6.0	9.5	0.50
			No. of Samples	15	7	15	12	15	11	15	14	14
		1,800	Median	9.1	......	......	......	......	......	......	......	......
			Average	....	5	2.0	7.6	45	3.8	12.5	10.9	0.80
			Maximum	240	20	2.4	7.7	48	7.0	18.0	12.8	2.1
			Minimum	3.6	0	1.2	7.4	38	2.0	7.0	9.6	0.41
			No. of Samples	15	8	15	13	15	12	15	15	15
		2,200			Canadian Shore							
Upper St. Marys River, Power Canal at Fort St. Bridge.	SMU-PC 0.1	100	Median	9.1	......	......	......	......	......	......	......	......
			Average	....	......	2.2	7.7	46	4	16.5	10.4	0.57
			Maximum	23	......	2.4	7.8	47	5	18.0	10.6	1.2
			Minimum	3.6	......	2.0	7.6	45	3	16.0	10.2	0.28
			No. of Samples	5	......	5	4	5	5	5	5	5
Lower St. Marys below Soo Locks.	SMD-0.8	100	Median	4,600	......	......	......	......	......	......	......	......
			Average	....	1	2.9	7.7	45	2.1	13.0	10.6	0.76
			Maximum	92,000	12	12	8.4	48	4.2	18.5	13.0	1.80
			Minimum	140	0	1.6	7.3	40	0.5	6.0	9.2	0.0
			No. of Samples	62	39	52	52	51	54	42	48	50
		900	Median	2,400	......	......	......	......	......	......	......	......
			Average	....	1	4.0	7.8	44	1.5	14.0	10.5	0.61
			Maximum	17,000	5	7.6	8.5	48	3	18.5	13.0	1.45
			Minimum	20	0	2.0	7.3	40	0.7	5	9.1	0
			No. of Samples	59	36	17	23	16	20	35	34	34
		1,500	Median	36	......	......	......	......	......	......	......	......
			Average	....	1	2.7	7.7	44	1.9	13.0	10.5	0.58
			Maximum	17,000	10	7.7	8.5	50	4.0	18.5	13.0	1.8
			Minimum	<1.8	0	1.4	7.3	40	0.6	6.0	9.2	0
			No. of Samples	61	45	50	52	50	53	42	49	52
		1,700			International Boundary							
		2,000	Median	23	......	......	......	......	......	......	......	......
			Average	....	2	3.5	7.7	44	1.5	14.0	10.5	0.67
			Maximum	5,400	14	8.5	8.5	48	3	18.5	13.2	2.25
			Minimum	<1.8	0	2.0	7.4	40	0.6	6	9.0	0.26
			No. of Samples	61	49	19	24	17	23	34	35	36
		2,300	Median	230	......	......	......	......	......	......	......	......
			Average	....	9	1.9	7.5	46	3.0	14.5	10.4	0.85
			Maximum	24,000	40	3.0	7.8	48	4.2	18.5	12.5	2.65
			Minimum	9.1	0	1.5	7.4	42	2.4	7.0	9.3	0.28
			No. of Samples	30	29	13	15	13	13	30	29	29

Table SM-6—Summary of Average Analytical Results—St. Marys River—Continued

Sampling Point	Mileage Index No.	Feet from U. S. Shore		Coliforms M.P.N. per 100 ml.	Phenols ppb	Chlorides ppm	pH	Alkalinity ppm	Turbidity ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm
Lower St. Marys River below Soo Locks. (Continued).	SMD-0.8	2,500	Median	5,400	......	......	......	......	......	......	......	......
			Average	......	27	2.5	7.6	44	2.3	13.5	10.3	2.27
			Maximum	110,000	80	6.8	8.5	48	4.0	18.5	12.9	3.99
			Minimum	430	0	1.2	7.2	40	0.8	6.0	9.0	1.10
			No. of Samples	64	54	52	52	50	55	42	50	52
		2,500			Canadian Shore							
Lower St. Marys River, Power Canal at Portage Street Bridge	SMD-PC 1.5	100	Median	43	......	......	......	......	......	......	......	......
			Average	......	......	2.2	7.7	47	4	16.5	10.3	0.66
			Maximum	150	......	2.3	7.8	49	5	18.0	10.6	1.8
			Minimum	7.3	......	2.0	7.7	45	3	15.5	10.1	0.22
			No. of Samples	5	......	5	4	5	5	5	5	5
Lower St. Mary's River at Power House.	SMD-1.0	600	Median	460	......	......	......	......	......	......	......	......
			Average	......	1	1.8	7.5	45	1.7	13.5	9.9	0.34
			Maximum	1,500	6	1.8	7.7	46	3.0	15.5	10.0	0.39
			Minimum	43	0	1.7	7.3	44	1.1	10.0	9.8	0.31
			No. of Samples	5	5	4	5	5	4	5	3	3
		400	Median	93	......	......	......	......	......	......	......	......
			Average	......	0	1.7	7.5	44	1.6	13.5	9.9	0.49
			Maximum	240	1	2.0	7.7	45	2.5	15.5	9.9	0.57
			Minimum	23	0	1.6	7.3	44	1.0	10.0	9.9	0.40
			No. of Samples	5	5	5	5	5	5	5	3	3
		200	Median	23	......	......	......	......	......	......	......	......
			Average	......	0	1.8	7.6	45	1.5	13.5	10.0	0.49
			Maximum	43	1	1.9	7.7	46	2.3	15.5	10.0	0.56
			Minimum	7.3	0	1.7	7.4	44	1.0	10.0	9.9	0.43
			No. of Samples	5	5	4	5	5	4	5	3	3
Lower St. Marys River below Power House.	SMD-1.2	200	Median	43	......	......	......	......	......	......	......	......
			Average	......	2	1.7	7.5	45	1.8	13.0	9.9	0.39
			Maximum	43	10	1.9	7.7	45	3.8	15.5	10.0	0.43
			Minimum	14	0	1.6	7.4	43	0.8	11.0	9.9	0.34
			No. of Samples	5	5	5	5	5	5	5	3	3
		400	Median	23	......	......	......	......	......	......	......	......
			Average	......	3	1.6	7.5	44	1.9	13.5	9.9	0.42
			Maximum	4,600	10	1.8	7.7	45	2.5	15.5	10.0	0.47
			Minimum	23	0	1.6	7.4	44	1.1	11.0	9.8	0.40
			No. of Samples	5	5	4	5	4	4	5	3	3
		600	Median	23	......	......	......	......	......	......	......	......
			Average	......	2	1.7	7.5	44	1.9	13.5	9.9	0.43
			Maximum	430	12	1.8	7.7	45	2.6	15.5	10.0	0.47
			Minimum	3.9	0	1.5	7.3	43	0.9	11.0	9.8	0.39
			No. of Samples	5	5	3	4	3	3	5	3	3
		900	Median	23	......	......	......	......	......	......	......	......
			Average	......	0	1.8	7.5	45	1.5	13.5	9.9	0.34
			Maximum	93	1	1.9	7.7	45	2.5	15.5	10.0	0.44
			Minimum	9.1	0	1.7	7.4	44	0.8	11.0	9.8	0.26
			No. of Samples	5	5	5	5	5	5	5	3	3
Lower St. Marys River below Sault Ste. Marie.	SMD-2.0	100	Median	930	......	......	......	......	......	......	......	......
			Average	......	1	2.7	7.7	45	2.2	13.2	10.7	0.57
			Maximum	46,000	10	7.0	8.4	48	18.5	18.5	13.0	1.80
			Minimum	22	0	1.2	7.3	40	0.2	7.0	9.2	0
			No. of Samples	66	41	53	52	50	56	45	50	54
		500	Median	370	......	......	......	......	......	......	......	......
			Average	......	2	2.4	7.7	42	1.2	13.5	10.6	0.50
			Maximum	4,600	15	2.7	8.4	48	3	18.5	13.2	1.05
			Minimum	3.6	0	2.0	7.3	40	0.4	6.0	9.0	0.05
			No. of Samples	44	27	8	16	8	10	38	31	30
		1,500	Median	93	......	......	......	......	......	......	......	......
			Average	......	1	4.2	7.7	45	1.6	14.5	10.1	0.59
			Maximum	1,600	7	10	8.2	47	3.8	18.5	12.4	1.40
			Minimum	3.0	0	1.2	7.4	43	0.5	7.0	9.2	0.29
			No. of Samples	55	28	15	17	13	16	33	34	36

TABLE SM-6—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. MARYS RIVER—Continued

Sampling Point	Mileage Index No.	Feet from U. S. Shore		Coliforms M.P.N. per 100 ml.	Phenols ppb	Chlorides ppm	pH	Alkalinity ppm	Turbidity ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm
Lower St. Marys River below Sault Ste. Marie (Continued).	SMD-2.0	2,100			International Boundary							
		2,100	Median	43	.....	.....	.....	.....	.....	.....	.....	.....
			Average	....	1	3.0	7.7	45	1.7	13.5	10.5	0.57
			Maximum	1,600	8	11.0	8.5	49	3.3	18.5	13.1	1.60
			Minimum	<1.8	0	1.5	7.3	41	0.4	6.0	9.4	0
			No. of Samples	65	47	49	48	46	50	39	49	51
		3,000	Median	240	.....	.....	.....	.....	.....	.....	.....	.....
			Average	....	4.1	4.6	7.7	46	1.5	14.5	10.1	0.84
			Maximum	>16,000	25	10.3	7.9	48	3	18.5	12.5	2.70
			Minimum	7.3	0	1.3	7.4	44	0.7	7.0	8.9	0.30
			No. of Samples	55	43	14	16	13	16	33	34	36
		3,500	Median	2,400	.....	.....	.....	.....	.....	.....	.....	.....
			Average	....	11	2.3	7.6	43	1.7	13.2	10.7	1.11
			Maximum	24,000	30	3.6	8.0	48	3.3	19.0	13.1	2.21
			Minimum	49	0	1.5	7.3	40	0.7	6.0	9.1	0.51
			No. of Samples	44	42	17	22	17	18	44	44	43
		4,000	Median	4,600	.....	.....	.....	.....	.....	.....	.....	.....
			Average	....	18	2.5	7.6	44	2.1	13.0	10.3	1.66
			Maximum	92,000	45	7.0	8.4	48	3.8	19.5	12.8	3.22
			Minimum	230	0	1.0	7.0	39	0.7	6.0	8.5	0.50
			No. of Samples	66	55	52	52	49	56	44	49	54
		4,300			Canadian Shore							
		0			United States Shore							
Lower St. Marys River, Mission Point to Sugar Island at Ferry Crossing.	SMD-3.1w	100	Median	220	.....	.....	.....	.....	.....	.....	.....	.....
			Average	....	2	2.2	7.7	43	1.7	10.0	12.3	0.86
			Maximum	1,600	10	2.8	8.4	49	3.5	12.5	13.2	1.65
			Minimum	70	0	1.6	6.9	41	0.5	6.0	10.9	0.50
			No. of Samples	19	16	13	15	13	15	15	10	9
		500	Median	43	.....	.....	.....	.....	.....	.....	.....	.....
			Average	....	1	2.3	7.7	43	1.6	9.7	12.1	0.80
			Maximum	540	7	3.2	8.5	48	3.4	12.5	13.3	1.35
			Minimum	4.5	0	1.6	7.4	40	0.4	6.0	10.8	0.20
			No. of Samples	29	27	25	28	25	29	29	29	27
		900	Median	93	.....	.....	.....	.....	.....	.....	.....	.....
			Average	....	0.5	2.3	7.7	42	1.7	9.9	12.4	0.84
			Maximum	540	2	3.0	8.5	46	3.7	12.5	13.1	1.35
			Minimum	23	0	1.6	7.0	40	0.6	6.0	11.2	0.30
			No. of Samples	19	17	13	15	13	15	15	10	9
		950			West Shore of Sugar Island, United States							
		0			United States Shore							
Lower St. Marys River, West Sugar Island Channel at Frechette Point.	SMD. 5.3w	100	Median	300	.....	.....	.....	.....	.....	.....	.....	.....
			Average	....	2	1.9	7.8	47	2	17.0	9.8	0.37
			Maximum	2,400	6	2.1	7.8	47	3	18.5	11.4	0.57
			Minimum	93	0	1.8	7.7	47	2	9.0	9.3	0.15
			No. of Samples	12	9	2	2	2	2	12	12	12
		500	Median	93	.....	.....	.....	.....	.....	.....	.....	.....
			Average	....	1	3.2	7.8	46	1.9	17.0	9.8	0.43
			Maximum	540	12	7.6	8.2	48	3	18.5	11.3	0.80
			Minimum	23	0	1.8	7.5	44	0.8	9.0	9.2	0
			No. of Samples	26	19	19	19	20	19	12	20	21
		900	Median	93	.....	.....	.....	.....	.....	.....	.....	.....
			Average	....	2	2.1	7.5	45	2	17.0	9.9	0.46
			Maximum	>2,400	15	2.3	7.7	46	3	18.5	11.4	0.68
			Minimum	23	0	1.9	7.3	44	2	9.0	9.6	0.20
			No. of Samples	12	9	2	2	2	2	12	12	12
		1,000			West Shore of Sugar Island, United States							

TABLE SM-6—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. MARYS RIVER—Continued

Sampling Point	Mileage Index No.	Feet from U. S. Shore		Coliforms M.P.N. per 100 ml.	Phenols ppb	Chlorides ppm	pH	Alkalinity ppm	Turbidity ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm
		0			United States Shore							
Lower St. Marys River, W. Neebish Channel, at Lights 19 and 20.	SMD-18.1w	150	Median	150								
			Average		1	2.6	7.7	45	3.3	13.5	10.4	0.54
			Maximum	1,600	15	7.5	7.9	48	8.0	20.0	12.5	1.20
			Minimum	<3.6	0	1.7	7.4	36	1.1	7.0	8.9	0
			No. of Samples	28	23	26	26	26	24	19	25	27
		300			West Shore of Neebish Island, United States							
		0			North Shore, Neebish Island, United States							
Lower St. Marys River, Middle Neebish Channel at Light No. 40.	SMD-16.9M	600	Median	79								
			Average		1	2.4	7.7	43	1.8	10.0	12.0	0.91
			Maximum	170	3	3.3	8.5	48	2.4	13.	12.9	2.05
			Minimum	7.8	0	1.4	7.5	40	0.8	7	10.4	0.20
			No. of Samples	15	15	13	14	13	15	15	15	15
		1,400			South Shore at Sugar Island, United States							
		0			East Shore of Neebish Island, United States							
Lower St. Marys River, Middle Neebish Channel at Johnson Point.	SMD-22.6M	100	Median	43								
			Average		0	1.7	7.7	47	2.3	18.0	9.9	0.32
			Maximum	150	1	1.9	7.8	47	2.6	19.5	12.4	1.00
			Minimum	23	0	1.4	7.5	46	2.0	8.0	9.1	0.32
			No. of Samples	7	6	2	2	2	2	7	7	5
		500	Median	86								
			Average		1	3.6	7.8	45	2.6	17.5	9.7	0.50
			Maximum	>1,600	2	7.0	7.9	46	4.0	20.0	12.5	1.20
			Minimum	43	0	1.4	7.5	44	1.1	8	9.2	0.20
			No. of Samples	16	13	12	13	12	13	7	13	14
		900			International Boundary							
		900	Median	43								
			Average		1	2.0	7.6	47	2.2	17.5	10.0	0.61
			Maximum	240	3	2.1	7.7	47	2.4	20.0	12.5	1.7
			Minimum	23	0	1.8	7.5	46	2.0	8.0	9.4	0.22
			No. of Samples	7	7	2	2	2	2	7	7	7
		0			North Shore of Lower Hog Island, Canada							
Lower St. Marys River, Lake George Channel, below Black Point.	SMD-4.2E	200	Median	280								
			Average		3	2.3	7.7	43	1.6	12.5	11.5	0.81
			Maximum	4,600	35	3.0	8.5	47	3	18.5	13.1	2.35
			Minimum	14	0	1.2	7.3	40	0.6	6.0	9.5	0.05
			No. of Samples	41	37	26	30	26	31	41	41	41
		500	Median	930								
			Average		4	2.7	7.7	44	1.4	12.0	10.9	0.93
			Maximum	11,000	20	7.0	8.5	48	3.9	18.5	12.9	2.65
			Minimum	23	0	1.2	7.3	40	0.4	6.0	9.0	0.00
			No. of Samples	63	51	47	51	48	54	42	52	51
		800	Median	3,500								
			Average		11	2.4	7.6	43	1.7	12.0	11.0	1.44
			Maximum	24,000	45	3.0	8.5	47	3.2	19.0	12.8	2.60
			Minimum	93	0	1.7	7.1	40	0.8	6.0	8.8	0.43
			No. of Samples	42	40	26	31	26	30	41	41	4
		900			Canadian Shore							
		0			North Shore of Sugar Island, United States							
Lower St. Marys River, Lake George Channel, Palmers Point to Belle Point.	SMD-8.5E	100	Median	930								
			Average		1	2.7	7.7	41	1.2	10.5	11.9	1.19
			Maximum	1,600	7	3.0	8.4	44	2.5	13.5	12.7	2.50
			Minimum	95	0	1.6	7.4	40	0.7	8.0	10.6	0.44
			No. of Samples	14	13	8	12	9	10	12	10	10

TABLE SM-6—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. MARYS RIVER—Continued

Sampling Point	Mileage Index No.	Feet from U. S. Shore		Coliforms M.P.N. per 100 ml.	Phenols ppb	Chlorides ppm	pH	Alkalinity ppm	Turbidity ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm
Lower St. Marys River, Lake George Channel, Palmers Point to Belle Point (Continued).	SMD-8.5E	500	Median	1,700	......	......	......	......	......	......	......	......
			Average	....	4	2.2	7.6	43	1.3	11.0	11.6	1.06
			Maximum	3,500	18	3.0	8.4	47	2.3	13.0	12.5	2.35
			Minimum	140	0	1.2	7.4	40	0.7	7.0	10.2	0.53
			No. of Samples	16	16	13	15	13	15	14	15	15
		600			International Boundary							
		800	Median	16,000	......	......	......	......	......	......	......	......
			Average	....	6	2.6	7.6	42	1.3	11.0	11.6	1.23
			Maximum	11,000	35	3.0	8.4	46	2.5	13.5	12.6	2.45
			Minimum	230	0	1.6	7.4	40	0.8	7.5	10.4	0.44
			No. of Samples	14	13	9	12	10	11	12	11	11
		1,100			Canadian Shore							
		0			East Shore of Sugar Island, United States							
Lower St. Marys River, Lake George Channel, Churchville Point to Sand Island.	SMD-14.2E	200	Median	920	......	......	......	......	......	......	......	......
			Average	....	4	2.8	7.7	41	1.0	10.5	11.6	1.11
			Maximum	2,400	30	3.0	8.4	41	1.5	13.5	12.6	1.80
			Minimum	240	0	2.5	7.5	40	0.7	8.0	10.2	0.73
			No. of Samples	13	13	6	9	6	8	11	10	9
		600	Median	930	......	......	......	......	......	......	......	......
			Average	....	6	2.3	7.6	42	1.3	10.5	11.6	1.09
			Maximum	3,500	45	3.3	8.4	44	2.4	13.0	12.5	1.55
			Minimum	240	0	1.2	7.4	40	0.8	7.5	10.2	0.64
			No. of Samples	15	15	13	15	13	15	15	15	15
		800			International Boundary							
		1,000	Median	930	......	......	......	......	......	......	......	......
			Average	....	3	3.0	7.7	40	1.1	9.0	11.7	1.12
			Maximum	3,500	16	3.3	8.4	41	1.5	13.0	12.1	1.85
			Minimum	170	0	2.8	7.5	39	0.8	7.5	10.3	0.65
			No. of Samples	13	13	7	9	7	9	11	10	10
		1,300			Canadian Shore							
		0			East Shore of Sugar Island, United States							
Lower St. Marys River, at Head of Lake George, Sugar Island to Sand Island.	SMD-15.0E	1,000	Median	350	......	......	......	......	......	......	......	......
			Average	....	3	1.6	7.5	44	1.9	11.0	11.0	1.0
			Maximum	1,500	16	2.0	7.5	45	2.3	12.0	11.5	1.3
			Minimum	49	0	1.4	7.4	42	1.4	10.0	10.2	0.7
			No. of Samples	13	12	4	4	4	4	4	3	3
		4,000	Median	230	......	......	......	......	......	......	......	......
			Average	....	3	1.8	7.4	44	1.5	10.0	10.4	0.62
			Maximum	4,600	16	1.8	7.4	44	1.5	10.0	10.5	0.75
			Minimum	46	0	1.8	7.4	44	1.5	10.0	10.2	0.49
			No. of Samples	13	13	1	1	1	1	2	2	2
		7,000	Median	540	......	......	......	......	......	......	......	......
			Average	....	10	2.4	7.6	42	1.4	11	11.5	0.95
			Maximum	4,600	90	3.3	8.4	45	3.8	14	12.4	1.45
			Minimum	91	0	1.5	7.4	39	0.7	8	10.5	0.49
			No. of Samples	15	14	13	15	13	15	15	15	15
		7,400			International Boundary							
		10,000	Median	130	......	......	......	......	......	......	......	......
			Average	....	4	......	......	......	......	10.8	10.1	0.80
			Maximum	1,600	16	......	......	......	......	11.5	10.1	0.80
			Minimum	13	0	......	......	......	......	10.0	10.1	0.80
			No. of Samples	13	13	......	......	......	......	2	1	1
		12,000	Median	170	......	......	......	......	......	......	......	......
			Average	....	2	1.7	7.5	44	2.1	11.5	10.8	0.85
			Maximum	1,600	15	2.0	7.5	44	3.0	13	11.3	1.20
			Minimum	22	0	1.5	7.4	43	1.5	10.0	10.1	0.74
			No. of Samples	13	12	4	4	4	4	4	3	3
		13,000			Canadian Shore							

TABLE SM-6—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. MARYS RIVER—Continued

Sampling Point	Mileage Index No.	Feet from U. S. Shore		Coliforms M.P.N. per 100 ml.	Phenols ppb	Chlorides ppm	pH	Alkalinity ppm	Turbidity ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm
		0			East Shore, Sugar Island, United States							
Lower St. Marys River, Lake George East-West Range at Hay Point.	SMD-18.0E	1,000	Median	49								
			Average		6	1.6	7.5	47	7.5	13	11.2	0.60
			Maximum	350	20	1.6	7.5	47	7.5	13	11.2	0.60
			Minimum	13	0	1.6	7.5	47	7.5	13	11.2	0.60
			No. of Samples	11	6	1	1	1	1	1	1	1
		4,000	Median	130								
			Average		1	1.8	7.5	45	2.0	10.8	10.4	0.74
			Maximum	1,600	10	2.0	7.5	45	2.5	11.0	10.8	0.94
			Minimum	27	0	1.6	7.4	45	1.6	10.5	10.0	0.53
			No. of Samples	13	13	2	2	2	2	2	2	2
		6,500			International Boundary							
		7,000	Median	230								
			Average		3	2.4	7.6	41	1.9	10.5	11.5	0.91
			Maximum	930	16	3.2	8.4	44	4.7	14.0	12.2	1.95
			Minimum	46	0	1.4	7.5	39	0.7	11	10.7	0.40
			No. of Samples	13	13	11	13	11	13	13	13	13
		10,000	Median	130								
			Average		2	......	......	......	......	......	......	......
			Maximum	920	12	......	......	......	......	......	......	......
			Minimum	7.8	0	......	......	......	......	......	......	......
			No. of Samples	11	11	......	......	......	......	......	......	......
		12,000	Median	130								
			Average		1	1.4	7.5	43	3.4	12	11.2	0.80
			Maximum	4,600	10	1.4	7.5	43	3.4	12	11.2	0.80
			Minimum	9.3	0	1.4	7.5	43	3.4	12	11.2	0.80
			No. of Samples	11	11	1	1	1	1	1	1	1
		15,000			Canadian Shore							
		0			East Shore of Sugar Island, United States							
Lower St. Marys River, Mouth of Lake George, Duck Island to Birch Point.	SMD-25.0E	500	Median	23								
			Average		0	......	7.5	......	......	10.8	9.7	0.42
			Maximum	930	1	......	7.5	......	......	11.5	9.7	0.42
			Minimum	4.5	0	......	7.5	......	......	10.0	9.7	0.42
			No. of Samples	13	11	......	1	......	......	2	1	1
		1,100	Median	23								
			Average		2	2.3	7.7	42	3.4	13.0	10.8	0.75
			Maximum	430	16	3.2	8.4	47	8.2	15.5	11.5	1.50
			Minimum	3.6	0	1.0	7.4	39	1.5	10.0	9.6	0.50
			No. of Samples	15	15	13	15	13	15	15	15	15
		1,300			International Boundary							
		1,700	Median	13								
			Average		1	2.9	7.7	40	2.9	13.0	10.9	0.76
			Maximum	930	5	3.2	8.4	41	4.4	15.5	11.5	1.50
			Minimum	3.6	0	2.3	7.5	39	1.5	10.0	9.9	0.50
			No. of Samples	13	11	7	10	7	9	11	10	10
		2,000			Canadian Shore							
		0			North Shore of St. Joseph Island, Canada							
Lower St. Marys River, St. Joseph Channel, Boulanger Point to Great Muskinonge Island.	SMD-30.0E	400	Median	240								
			Average		2	2.1	7.6	47	2.7	19.0	9.2	0.90
			Maximum	460	3	2.2	7.7	47	3.3	21.5	10.8	3.20
			Minimum	93	0	2.0	7.5	46	2.0	11.0	8.8	0.23
			No. of Samples	7	7	2	2	2	2	7	7	6
		1,000	Median	460								
			Average		2	3.2	7.7	46	2.6	20.0	9.1	0.59
			Maximum	>1,600	4	7.0	7.9	48	4	21.0	9.4	1.20
			Minimum	43	0	1.8	7.6	43	1.7	18.5	8.6	0.30
			No. of Samples	18	14	12	14	13	14	6	12	14

TABLE SM-6—SUMMARY OF AVERAGE ANALYTICAL RESULTS—ST. MARYS RIVER—Continued

Sampling Point	Mileage Index No.	Feet from U. S. Shore		Coliforms M.P.N. per 100 ml.	Phenols ppb	Chlorides ppm	pH	Alkalinity ppm	Turbidity ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm
Lower St. Marys River, St. Joseph Channel, Boulanger Point to Great Muskinonge Island (Continued).	SMD-30.0E	1,800	Median	200	......	......	......	......	......	......	......	......
			Average	....	2	2.0	7.7	48	2	20.0	9.1	0.54
			Maximum	460	4	2.0	7.7	48	2	21.0	9.2	0.79
			Minimum	93	0	2.0	7.7	48	2	18.5	9.0	0.38
			No. of Samples	6	6	1	1	1	1	6	6	6
		2,000			South Ca	Shore nada	of Gre	at Mu	skino	nge Is	land,	

over 400 times. In 1913 this increase was only 17 times.

Chemical analyses of samples taken in the upper St. Marys River showed a pattern of pollution similar to that indicated by the bacteriological examinations. Determination of phenols was the most significant for indicating industrial pollution. Phenols averaged less than 3 p.p.b., with the exception of a few shore points. A point 100 feet from shore, below the No. 2 tannery outfall of the Northwestern Leather Company, showed an average of 43 p.p.b. with a maximum of 350 p.p.b. Samples in the small bay upstream from the Algoma Steel Corporation's boat slip gave an average phenol content of 16 and maximum of 50 p.p.b.

The highest average concentration of phenols below the locks was found at the Canadian shore in the first sampling range, SMD-0.8, and amounted to 27 p.p.b. On the average, only a trace occurred in the balance of the range. One mile farther downstream the samples showed an average phenol content of 18 p.p.b for the shore point and a tendency toward dispersion across the stream. There was no evidence that phenols originating on the Canadian side crossed the International Boundary into the Lake Nicolet Channel at Sugar Island. Rather, the analytical results showed that these phenols traveled down the Lake George Channel and continued moderately high along the Canadian shore for a total distance of 8 miles below the locks. Beyond this point they were dispersed throughout the stream. While an average concentration of 4 p.p.b. remained at the entrance to Lake George, passage through the lake accomplished a reduction to trace proportions of the same magnitude as found in the upper river.

In the upper river a maximum phenol value of 350 p.p.b. was found in the vicinity of the tannery outfall. A high maximum value of 80 p.p.b. occurred in the Canadian side in the lower river at range SMD-0.8. At the entrance to Lake George the maximum was 45 p.p.b. Occasional values of 15 p.p.b. were found at shore points on the United States side for a distance of 18 miles below the locks through the Lake Nicolet and West Neebish Channels.

Dissolved oxygen and B.O.D. values in the upper river, with the exception of shore points influenced by industrial wastes, did not reveal any material effect of pollution. Dissolved oxygen values were normal, averaging from 9.5 to 12.5 p.p.m. in the main stream, with no serious depletion in the polluted shore areas. The biochemical oxygen demand was consistently low, less than 1 p.p.m., except in the immediate vicinity of the tannery outlets, where average values varied from 2 to nearly 10 p.p.m., with a single maximum of 37 p.p.m.

The highest B.O.D. values occurred at shore points immediately below both cities, ranging from an average of 0.86 p.p.m. to 2.3 p.p.m., with a value of 0.57 p.p.m. in midstream. A slightly higher than normal B.O.D was noticeable throughout the Lake George Channel Normal B.O.D. values in unpolluted sections of the upper St. Marys River were from 0.40 to 0.75 p.p.m. as compared to 0.90 p.p.m. in Lake George and 0.60 p.p.m. in the Munuscong Channel.

Somewhat lower B.O.D. values were found in the Lake Nicolet Channel. The average near the head of Sugar Island was 0.85 p.p.m., reducing to 0.45 p.p.m. in Lake Nicolet. It is significant that higher values occurred in the narrow navigation channels on both sides of Neebish Island.

No variation in dissolved oxygen could be attributed to pollution, with the exception of the shallow shore area opposite lower Sault Ste. Marie, Ontario. In this small area the current is slow, and the deposition of sewage and industrial waste solids on the river bed has created anaerobic conditions.

Turbidity values in the river were usually well below 10 p.p.m., with a maximum at one shore point of over 40 p.p.m. Alkalinity results were fairly constant, averaging between 41 and 48 p.p.m. Hydrogen ion concentrations averaged between 7.5 and 7.9.

Supplementary Information on Pollution Effects

The effects of pollution were revealed not only by the analytical results on river water samples but also through special studies. These included the municipal water supplies and microscopic examinations of bottom deposits in the river.

Municipal Water Supplies

The source of municipal water supply for Sault Ste. Marie, Ontario, is the upper St. Marys River. The intake is located on the offshore side of the Great Lakes Power Company's headrace. The quality of this water is influenced by land drainage from a large industrial area, cooling water and some industrial waste, runoff from the unsewered community near Davignon Creek, and vessels in the approach to the Canadian lock. These sources contribute some bacterial and phenolic pollution. They have had only intermittent effect on the quality of the water but their presence does constitute a potential hazard.

A special study on the quality of the Sault Ste. Marie, Ontario, water supply was conducted from May 20 to June 19, 1948. A total of 212 hourly samples, taken between 8 A. M. and 3 P. M. for 27 days, were analyzed for coliforms and phenols. The results are summarized in table SM-7.

TABLE SM-7—SPECIAL STUDY, SAULT STE. MARIE, ONTARIO, WATER SUPPLY

Percentage of Samples in Various Groups

Coliform Organisms (M.P.N. per 100 ml.)	%	Phenols (p.p.b.)	%
Less than 1.8	72.0	Zero phenol	81.6
2.0 to 4.5	21.6	Trace	15.5
6.8 to 33	6.4	4 to 8 p.p.b	2.9

This study indicates that bacterial pollution at this intake was not serious. However, it does not preclude the possibility of serious pollution, from sources already enumerated, under adverse conditions.

Similarly, phenols were seldom found in higher than trace proportions, and these amounts have been effectively handled by the chlorine-ammonia treatment. The relative positions of the water intakes and industrial outfalls, which might accidentally discharge by-product coke wastes and oils to the river, present a constant threat to the water supply.

The intake of the Sault Ste. Marie, Michigan, water works is also in the upper St. Marys River, 3.2 miles upstream from the United States locks. It is situated 1,600 feet offshore, opposite Big Point, in 42 feet of water. This intake is approximately a mile above the nearest source of industrial waste, but back eddies bring it under the influence of these wastes. Treatment of the water is by free chlorination. The bacterial quality of the raw water is indicated through analyses for the year 1946. For three months of this time the raw water showed no coliforms. The highest monthly average was 5 M.P.N.

The Michigan Department of Health reports that no unusual difficulty has been encountered in furnishing a safe and palatable water to the city from this source. Unconfirmed reports have indicated that wastes from the tannery reach the intake occasionally. Instances have occurred when river traffic has been blocked, causing a heavy concentration of vessels in the vicinity of the intake. It has then been necessary for the State Health Department to request withdrawal of the ships to Whitefish Bay to protect the supply against excessive bacterial contamination.

River Bottom Deposits

In August, 1947, a special study was made of bottom deposits in the St. Marys River in the vicinity of the two cities. Ashmun Bay, on the United States side, was seriously polluted by the outfalls from the Northwestern Leather Company tannery. The water was turbid and contained numerous floating balls of hair, some of which were detected in the international channel near Sugar Island. Chrome wastes at this point colored the sand of the bay, but this waste was not noticeable in the river proper.

Thin muddy deposits, composed chiefly of fine iron ore and coal dust, were noticeable in the vicinity of the Algoma Steel Corporation's dock. Bark from log booms above the locks also littered the immediate shore and bottom.

In the lower St. Marys River a heavy gelatinous and filamentous growth was abundant below the Abitibi Pulp and Paper Company's outfalls and enmeshed numerous paper fibers. The addition of waste from the steel plant and a large proportion of the domestic sewage from Sault Ste. Marie, Ontario, causes this growth to become profuse. Iron ore solids were embedded in this mass. Farther downstream the growth consisted of a zoogleal mass containing numerous algae and protozoa. The pollution and growth are carried downstream, and the first crossing of the boundary line was noted just upstream from Brassar Post Office, on Sugar Island, 8½ miles below the locks. Farther downstream the growth gradually diminished. Near Brassar Post Office balls of hair were seen occasionally, indicating that pollution from the United States also travels down the Lake George Channel.

Chapter SM-VIII

DISCUSSION OF FINDINGS AND REMEDIAL MEASURES

This report presents data on the results of the investigation of pollution in the Lake Superior-Lake Huron section of the boundary waters. The survey was prompted by a series of complaints about objectionable deposits along the Sugar Island shore line and elsewhere. Information was needed to determine the adverse effects of sewage and industrial wastes, from the two cities of Sault Ste. Marie, upon the uses of these waters. The information in this report has been obtained in accordance with the terms of reference to the Commission, to show the extent, nature, and sources of pollution, and in what localities such pollution occurs. The findings and conclusions of the Board are discussed herewith.

The area adjacent to this section of the boundary is growing in population and expanding as a tourist and recreational center. It possesses important industries and offers attractions for industrial expansion through an almost unlimited supply of water. The future development and welfare of these communities are closely related to those activities which require the maintenance of these waters free from objectionable pollution.

The 1913 Investigation

In 1913 the total urban population on the St. Marys River was 30,500 with concentrations of 12,500 at Sault Ste. Marie, Michigan and 18,000 at Sault Ste. Marie, Ontario. These two municipalities comprised practically the whole contributing population on the St. Marys River basin. Neither municipality provided sewage treatment, and the raw wastes were discharged through numerous outlets along both shores. No reference was made to the significance of industrial wastes although such Canadian industries as paper and steel mills were in operation at that time, as well as the tannery on the United States side.

The extent of the bacterial pollution in 1913 is detailed in chapter SM-VII. Lake Superior was found to be practically pure. The discharge of sewage from vessels was stated to pollute the waters seriously in the lanes of vessel traffic. Below the two municipalities the pollution was shown to increase to 291 B. coli per 100 c.c., and it was stated this serious condition continued, although in a less pronounced degree, down the river to Neebish Island.

Changes in Period 1913-1946

In the interim between the 1913 and 1946 investigations there has been a substantial increase in population which now totals 47,000, with a concentration of 17,300 on the United States side and 29,700 on the Canadian side. While there has been some increase in rural population, especially on the outskirts of the main cities, these figures are indicative of the increase in sewage pollution imposed upon the river. Some industrial expansion has taken place, but not to as marked an extent as in the Lake Huron-Lake Erie section. This growth has been largely in industries existing at that time.

In the public water supplies of this section no major change in treatment facilities has been made since 1913. Filtration has not been adopted, but improvements in chlorination practices have been introduced. Taste control has been put into practice on the Canadian side by the use of the chlorine-ammonia process.

No facilities have been provided for the treatment of sewage from the two principal centers of population, except for some very small areas. Some changes have been made in the outlets.

Extent and Effects of Pollution in 1946-1948

In preceding chapters, information has been presented to show the sources, character, and extent of the pollution that exists today. Laboratory results indicate that both domestic and industrial wastes are responsible for this pollution. The findings of the Board are discussed herewith in connection with the questions contained in the terms of reference.

Transboundary Crossing

The transfer of pollution from one side of the boundary to the other has been demonstrated in several instances. The natural conditions in this section are conducive to ready diffusion of waters across the stream from shore to shore. Such conditions include strong currents, sharp changes in direction, sudden narrowing of channels, falls and rapids, and islands or other physical barriers.

The pollution from both cities is discharged at the shores and would have a tendency to follow in these paths, but the force exerted through the diversion of water for power purposes on both sides induces more rapid diffusion across the river. This is supported by the presence of tannery wastes in the Lake George Channel, after passing through the Michigan Northern Power Company's canal, and the presence of paper fiber on the United States side of the Lake George Channel. The fact that the figures for coliform values and phenols in the Lake George Channel show an even distribution across the channel indicates a transfer of pollution from each side of the boundary to the other. Since pollution from each source tends to lose its identity, it is difficult to establish the magnitude of this transfer. The information available shows that most of the transboundary crossing takes place in the Lake George Channel.

Injury to Health

The danger to health in the use of these waters can be measured most readily by the coliform determinations, although constituents of a chemical nature also warrant consideration. As in the Lake Huron-Lake Erie section, the major uses of these waters include domestic water supply, bathing, and recreation, all of which are closely related to public health.

Limits of pollution beyond which a health menace exists are discussed in chapter X of the Lake Huron-Lake Erie section.

The principal public health significance of the pollution of these waters lies in the effects produced on public and vessel water supplies. While recognized measures of treatment such as chlorination offer protection against bacterial pollution, the proximity of pollution to the intake on the Canadian side and the possibility of vessels discharging sewage almost over the mouth of the intake on the United States side clearly emphasize the need for pollution control to protect public health. Chlorination has been effective thus far in controlling water-borne diseases in these two municipal supplies. The threat to these supplies is ever present as long as pollution from human origin in varying intensities exists. This danger is more intense in the upper reaches of the lower river where the M.P.N. values on the average exceed acceptable limits. In addition, phenols are sufficiently high to interfere with the development of public water supplies. They persist in such concentrations for a distance of 25 miles below the locks.

The extent of pollution in the navigation channels of this section of the boundary precludes the use of the waters on vessels without treatment.

In the upper river, except for localized areas, the water is of acceptable quality for bathing purposes. In much of the lower river the pollution is sufficiently high to create a health hazard to bathers.

Injury to Property

Injury to property is evidenced by deposition of solids of waste origin on water front property, interference with the development of bathing beaches, additional cost of water treatment at Sault Ste. Marie, Ontario, and fouling of shore areas by oil.

Sources of Pollution

Pollution in this section results from municipal sewage and industrial wastes containing solids, phenols, cyanides, ammonium compounds and oils.

The St. Marys River receives 6,620,000 U. S. (5,510,000 Imp.) gallons of untreated domestic sewage per day from a contributing population of some 46,000. Nearly all of this enters the river below the locks.

Industrial waste reaching the river amounts to 148,000,000 U. S. (124,000,000 Imp.) gallons per day of which 2,000,000 gallons originate on the United States side. About 22,000,000 Imperial gallons of this is cooling water. The daily discharge of the more significant of these wastes was found to be 280 pounds of phenols, 3,170 pounds of cyanides, 3,500 pounds of ammonium compounds, 850 Imperial gallons of oil, 79,800 pounds of suspended solids, and organic matter having a biochemical oxygen demand of 225,700 pounds.

At the height of the navigation season in 1947 the domestic sewage discharged from vessels navigating the St. Marys River was equivalent to that from a daily population of 1,000 persons, and amounted to an estimated 30,000 U. S. (25,000 Imp.) gallons per day. For the same period the estimated amount of garbage averaged 500 pounds per day. These quantities do not take into consideration the conditions which occur when a number of vessels are anchored above the locks due to bad weather which may delay their departure for days at a time.

Garbage and refuse disposal by the bordering municipalities of Sault Ste. Marie does not bear any significance to the pollution of these waters. On the United States side, the municipal dumping grounds are not located in proximity to boundary waters. On the Canadian side, garbage and refuse from the municipality is disposed of by incineration.

Remedial Measures

It has been shown that pollution in these waters has an injurious effect on drinking water supplies, bathing, and recreation. The nature, extent, and sources of the pollution have been discussed. Pollution crosses from each side of the boundary to the other. Measures for remedying this situation is the only remaining question in the reference.

Objectives for Boundary Waters Quality Control

Remedial measures involve the treatment or control of all sources of pollution reaching the boundary waters. The "Objectives for Boundary Waters Quality Control," formulated for the Lake Huron-Lake Erie section are also applicable to the Lake Superior-Lake Huron section. They are discussed and presented in chapter X.

Hearings Before the Commission

Public hearings for municipalities, industries, and all other interested parties were held by the Commission at Sault Ste. Marie, Ontario at the conclusion of the field studies. The purpose of these hearings was to obtain information on waste treatment processes now in use or proposed, cost estimates of remedial measures, time required to carry out these measures, and comments on the application of the objectives to specific wastes. The principal points developed at the hearings were as follows:

(a) The pollution of boundary waters between the United States and Canada reached such a degree of contamination as to stimulate complaints.

(b) The evidence brought out at the hearings indicates that the pollution affecting municipal water supplies is due both to industrial wastes and domestic sewage.

(c) Plans of industries for dealing with their waste problems indicate that most of the industries take their responsibilities for keeping deleterious wastes out of boundary waters seriously, and are making plans for treatment of their wastes.

(d) Plans for collecting and treating municipal wastes are completed by one municipality and in preparation by the other.

(e) The municipalities are inactive at the present time as far as the construction of works for treating their waste is concerned. Boundary waters are denied the benefits of municipal pollution control by the limited ability of communities to finance treatment works.

(f) The need for promptly providing funds to construct necessary municipal treatment works has been shown.

(g) The people living near the boundary waters have been denied the recreational use of certain areas of these waters because of pollution.

(h) To encourage recreational development and to assure future industries a supply of reasonably clean water for industrial purposes, it is necessary to curb the tendency toward increased pollution and to eliminate much of the waste now being added to these waters.

(i) Evidence has been presented that the International Joint Commission should maintain a continuing interest in the condition of these boundary waters, and that an effective way should be found to exercise such interest.

Pollution Control Program

The pollution problem must be considered in terms of the future as well as on the basis of present day needs. Municipal sewage treatment facilities should be planned to incorporate flexibility for expansion and to satisfy future demands. Treatment of industrial wastes must be not only adequate for the present, but the programs must ensure that new wastes or increase in wastes will not jeopardize the rights of users of these waters. Industry must continue to bear its responsibility for satisfactory disposal of its own wastes.

Disposal of Municipal Wastes

The immediate problem in the disposal of municipal wastes is centered in the Sault Ste. Marie area. The daily discharge of about 6,000,000 gallons of raw sewage imposes a heavy bacterial load on the river. This is evidenced in the lower river and down through the Lake George Channel.

It is the opinion of the Advisory Board that work should be initiated without delay on the construction of disposal works for primary treatment and disinfection of all domestic sewage from both cities. Provision should be made for secondary treatment as new factors affecting the problem are introduced. As the stream sanitation program progresses the need for additional control of pollution from combined sewer overflows will develop.

Disposal of Industrial Wastes

The volume of industrial wastes discharged directly into these waters is 148 million U. S. (123 million Imp.) gallons per day. This is nearly 25 times the volume of domestic sewage. Separation of these wastes in the industry may reduce the volume to be treated. Each waste must be considered individually in relation to the pollutants carried. All effluents should meet the objectives for boundary waters quality control, whether discharged through municipal outfalls or directly to the stream. This requires proper consideration for the prevention of slugs and spills.

Disposal of Other Wastes

Other wastes in this section come chiefly from navigation. Vessels contribute bacterial pollution through the discharge of sewage. This objectionable practice can be corrected by the use of sewage retention tanks, accompanied by some form of treatment or sterilization of the contents. This requirement should apply to commercial vessels equipped with flush toilets and to craft used for living purposes.

Progress in Pollution Control

No construction has yet been undertaken in the programs for treatment of the sewage from the two cities. Construction plans for interceptors and a primary treatment plant have been completed for Sault Ste. Marie, Michigan. An engineering report has been prepared for interceptors and a primary treatment plant for Sault Ste. Marie, Ontario.

The status of industrial waste treatment programs on each side of the boundary is as follows:

For Michigan:

Industry	*Present Status*
Northwestern Leather Company	
Sewage	Plans under way.
Industrial Waste	Plans completed.
Union Carbide and Carbon Company	
Sewage	Plans under way.
Industrial Waste	Control measures provided.

For Ontario:

Abitibi Power and Paper Company	
Sewage	Plans under way.
Industrial Waste	Studies under way.
Algoma Steel Corporation	
Sewage	Plans under way.
Industrial Waste	Studies under way but no construction of treatment works undertaken.
Dominion Tar and Chemical Company	
Sewage	Plans under way.
Industrial Waste	Alterations being made to eliminate the effects of spills.

Costs and Financing

The following estimates have been prepared on costs for remedial measures. The municipal costs are for interceptors and primary treatment. Costs for industries are estimated on the basis of compliance with the objectives for boundary waters quality control.

Costs for Municipalities:	
United States side	$1,250,000
Canadian side	2,750,000
Total municipal	$4,000,000
Costs for Industries:	
United States side	$ 150,000
Canadian side	350,000
Total industrial	$ 500,000
GRAND TOTAL	$4,500,000

Financial difficulties have created a strong deterrent against progress in water pollution programs. Remedial works for treating municipal sewage must be constructed through public funds. The problem in this respect is similar to that in the Lake Huron-Lake Erie section. Both cities have indicated difficulties in financing these necessary measures.

The Continuing Program

The pollution program is an ever changing one. The fulfillment of the objectives will need time and continuous supervision. It is believed that progress will be aided if a technical committee or board be established to maintain a continuing interest in the pollution problem. Such a committee would supplement and strengthen the efforts made by local authorities and would permit the interchange of reports on progress. This would be advantageous here as it would be for other sections of the boundary waters.

Lake Erie-Lake Ontario Section

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LETTER OF SUBMITTAL

(Lake Erie-Lake Ontario Section)

To the International Joint Commission
United States and Canada

The Board of Technical Advisers submits herewith its report on pollution in that section of the International Boundary Waters covered by the amended reference to the Commission, dated April 2, 1948.

Respectfully submitted,

THE BOARD OF TECHNICAL ADVISERS

United States	*Canada*
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M. LEBOSQUET, JR.	W. R. EDMONDS
EARL DEVENDORF	A. E. BERRY
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ACKNOWLEDGMENTS

(Lake Erie-Lake Ontario Section)

Valuable assistance has been rendered, during this investigation by the various municipalities and industries as well as several State, Provincial, and Federal agencies on both sides of the boundary. Special acknowledgement is made to the following:

On the United States side to:

Buffalo Sewer Authority
City of Niagara Falls
New York State Department of Health
New York State Conservation Department
New York State Air National Guard
U. S. Coast Guard, Ninth District
U. S. Corps of Engineers, Buffalo District
U. S. Geological Survey
U. S. Lake Survey
U. S. Public Health Service, Environmental Health Center

and on the Canadian side to:

City of Niagara Falls
Ontario Department of Health
Department of Mines and Resources
  Water and Power Bureau
  Mines and Geology Branch
Department of National Health and Welfare

PERSONNEL

(Lake Erie-Lake Ontario Section)

The personnel assigned for all or part time to conduct the field work in the 1948-1949 investigation were made available by the U. S. Public Health Service, the Department of National Health and Welfare of Canada, and the Ontario Department of Health as follows:

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- Roscoe H. Goeke, Sanitary Engineer, Officer in Charge
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*Deceased

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Chapter N-I

FINDINGS AND RECOMMENDATIONS

> "Nothing is difficult;
> it is only we who are indolent."
> —B. R. Haydon

This investigation of pollution of the boundary waters in the Lake Erie-Lake Ontario Section extended from July 1948 to November 1949. A comprehensive examination has been made of all types of pollution. Additional information has been secured from a number of sources. A detailed study of these data has enabled the Board of Technical Advisers to reach conclusions on the questions contained in the terms of reference to the International Joint Commission by the Government of the two countries.

This investigation was carried on following the 1948 study of pollution in the Lake Huron-Lake Erie and the Lake Superior-Lake Huron Sections. The first investigation of boundary waters was made in 1913 when bacteriological tests were the primary means of measuring pollution. In the intervening 36 years, tremendous changes in the Niagara area have taken place. These have had a strong influence on the numerous uses which these boundary waters have been called upon to serve. Greater emphasis has been placed on those conditions which promote healthful living, commerce, and recreation on both sides of the boundary. All these requirements have directed public attention to the need for clean waters and to the problem of reaching that objective. This investigation has called for the application of entirely new methods to those used in 1913. These have been developed to measure the effects of concentration of population and the operation of many and varied industrial plants. Remedial measures call for restoration of the waters to suitable quality.

The investigation has enabled the Board of Technical Advisers to reach certain conclusions on the findings and to offer recommendations to the Commission for remedial measures. The findings of the Board are discussed in chapter N-IX and are summarized herewith.

Findings

1. These boundary waters are seriously polluted from Lake Erie to Lake Ontario. The most serious pollution exists along the United States side of Lake Erie and the upper Niagara River, and due to stratification of the flowing water, is confined largely to zones paralleling the shore. This phenomenon disappears as the water passes over the Falls and through the rapids, thereby diluting and mixing wastes throughout the total volume of water.
2. The westerly part of the upper Niagara River was found to be of good sanitary quality. This water flows directly from the central part of Lake Erie.
3. There is a transfer of pollution from each side of the boundary to the other, especially pronounced in the lower Niagara River. This has been demonstrated by float studies, by visual observations, by analytical results, and by discharges of specific substances.
4. There has been injury to health and property on both sides of the boundary. This has been manifested in the following ways:
   a. Health—A potential menace is present where waters polluted to the extent of these are used for domestic purposes. They are in such condition that they cannot be safely used as a potable supply without complete and continuously effective treatment. Much of the threat to health arises from such factors as bacterial overloading beyond the safe limits of water purification processes; sudden variations in pollution with accompanying erratic chlorine demand; interference of certain types of pollution with disinfectants which destroy their germicidal properties; and the probability of certain infections being carried through a water treatment process, especially if there is any interruption or breakdown in a part of that process. This situation occurred in Niagara Falls, New York, in 1933 when approximately 10,000 cases of gastroenteritis were reported among the water consumers.

   These waters are so polluted in many areas as to render them unsafe for bathing purposes.

   The sewage pollution present in these boundary waters must be considered as an actual and potential health hazard, whether it be through public water supplies, bathing beaches, or other vectors.

b. Property—Injury to property has been illustrated in the cost of extending water intakes and for water treatment, both for municipalities and industries; in economic loss to owners of bathing beaches and other waterfront property; in damage to watercraft; and in destruction of fish and wildlife.

c. Industry—There is evidence that these waters are polluted to such a degree as to affect their use in certain industries. An economic loss to the community, and to industry as well, will occur when a plant is unable to expand or to locate in an area because of inability to secure a satisfactory water supply.

5. Pollution of these boundary waters increased markedly from 1913 to 1936 due to a steady growth in population and major industrial expansion. Since 1936 substantial progress has been made in the control or elimination of pollution. Both municipalities and industries have contributed to this activity.
6. Public hearings held by the Commission revealed a common acceptance on the part of municipal officials and industrial management of the presence of serious pollution in these waters and the need for correction. The hearings also substantiated the findings of the Advisory Board that there was injury to health and property and interference with the various water uses on both sides of the boundary. Financing of the necessary remedial works was asserted by municipal officials to be the principal obstacle to correction.
7. Municipalities along the upper Niagara River have shown an interest in extending their water intakes beyond the zone of pollution along the United States shore.
8. Dredging in the interior of Strawberry Island under the conditions specified in the permit issued by the Corps of Engineers, U. S. Department of the Army, dated May 5, 1947, will not change the hydraulic regimen or currents in the Niagara River.
9. The frequent slug-type releases of pollution into the Upper Niagara River, particularly from the Buffalo River and harbor area, are of serious import. These are due to changing meteorological conditions and oscillations in lake level.
10. The condition of these waters requires that remedial measures be undertaken as early as possible.

Recommendations

The Board of Technical Advisers recommends to the Commission that:

1. Remedial measures for the abatement and control of pollution in the Lake Erie-Lake Ontario Section of the boundary waters be undertaken at the earliest possible date. These measures should be sufficient to restore and protect the uses of these waters to which the people of both countries are rightfully entitled. Major consideration should be given to uses for domestic and industrial water supplies, recreation, fish and wildlife, sanitary purposes, navigation and power.
2. The "Objectives for Boundary Waters Quality Control," prescribed in this report, be recognized in the development of remedial and preventive measures by municipalities and industry. These objectives should apply to both existing and new sources of wastes.
3. Treatment of municipal wastes by effective sedimentation and disinfection of the effluent be undertaken by all communities, and that a median coliform M.P.N. value not exceeding 2,400 per 100 ml., as set forth in the "Objectives for Boundary Waters Quality Control" at any point in these waters, following initial dilution of waste discharges, be considered as the objective for bacterial control to attain reasonable stream sanitation. It is recognized that local conditions, on either side of the boundary, may give additional emphasis to a need for higher degree of treatment. Major population growth or industrial expansion may precipitate conditions in the future which will materially alter the requirements of treatment necessary to meet the Objectives. The estimated cost for installation of intercepting sewers and primary treatment works for municipalities in this section is $9,500,000, of which $7,250,000 is for United States and $2,250,000 for Canadian communities. These works must be financed through public funds.
4. Every effort be made to maintain the high natural quality of the water in those parts of the upper Niagara River not now polluted. Since this water should continue to be of higher quality irrespective of the degree of treatment of sewage and industrial wastes, municipalities should endeavor to extend their water intakes into this water

and beyond the zone of pollution along the easterly shore.

5. Overflows from combined sewers during storm periods be treated by sedimentation and disinfection or by other methods where necessary to protect these waters for the purposes for which they are or may be utilized.
6. Industrial wastes be treated to comply, as soon as possible, with the "Objectives for Boundary Waters Quality Control." The total estimated cost for industrial waste treatment works is $9,600,000. The cost on the United States side is $9,500,000, including the Lake Erie Cooling Water Project, and on the Canadian side it is $100,000. The problem of industrial waste disposal is the responsibility of industry.
7. The Buffalo River pollution abatement program including the Lake Erie Cooling Water Project be encouraged as an aid in further protecting the quality of the boundary waters.
8. Slugs and spills of objectionable wastes from industrial plants be avoided. Retention tanks or lagoons with provisions for equalizing rates of discharge be utilized where slugs and spills cannot otherwise be controlled.
9. Sewage from vessels equipped with flush toilets and from craft used for living purposes be controlled by the installation of holding tanks, and that the tanks be emptied either by transfer of the contents to shore treatment facilities or disinfected and dumped overboard in nonrestricted areas. No garbage or other refuse be discharged overboard into these waters.
10. Materials from dredging operations be dumped only at locations where they will not interfere with legitimate water uses.
11. Definite plans for financing remedial municipal works be formulated. In this, there should be cooperation between the Commission and Federal, State, Provincial, and municipal governments.
12. Dams, canals, channels, power diversions, and other hydraulic structures on these waters, be planned with due consideration to their possible effects on water pollution.
13. Continuing contact with pollution control progress be maintained through a technical committee or board, having representation from both countries.
14. The Commission take such measures as may be legally available to it to have the pollution abatement and prevention program herein outlined initiated, promoted, and effectively prosecuted.

Chapter N-II

INITIATION OF THE INVESTIGATION

"I would live to study and not study to live."
—Francis Bacon, Letter to
King James The First

The Pollution Problem

The waters between the United States and Canada comprise the largest body of fresh water in the world. They are vitally important to health, recreation and the national economy of both countries. Large populations and great industries have developed along the shores of these watercourses, attracted by natural water resources so essential for domestic and industrial water supplies, recreation, the reception of wastes, and for transportation and power. The success of these developments, and indirectly, of larger areas of both countries, is influenced in no small measure by maintenance of these waters free from objectionable pollution.

Pollution control is a world-wide and an ever-changing problem, intensified in those watercourses subject to a variety of riparian activities. Domestic sewage was at one time the major source of contamination, and the degree of bacterial pollution was the primary concern. This continues to be an important health problem, but industrial developments on both sides of the boundary have added new and complex factors. Wastes from industry produce effects additional to and different from those created by sewage. All or any of these industrial wastes may have a deleterious effect on the aesthetic qualities of the waters as well as on their physical and chemical properties. Their health significance is secondary to that of sewage, but they may seriously impair the use of water for domestic, recreational, industrial, and other purposes. The development of new products, the expansion of industrial activity, and modifications of industrial processes all may cause alterations in wastes which intensify the problems of water pollution control. This is further aggravated by the present day demand for the widest and fullest use of these waters by populations adjacent to the boundary.

The Previous Investigation

The pollution of boundary waters between the United States and Canada has been of concern to both countries for more than forty years. Interest has been manifest in the extent, nature, and dispersion of pollution from one side of the boundary to the other. A solution to this problem was first attempted in a comprehensive survey of these waters undertaken in 1913 by the International Joint Commission. The "Progress Report of the International Joint Commission," dated January 16, 1914, showed clearly the extent of bacterial pollution at that time. The "Report of the Consulting Sanitary Engineer upon Remedial Measures," dated March 8, 1916, recommended procedures for abating this pollution.

In the interval between 1913 and 1948, some sewage treatment plants were constructed in the Niagara River area. However, much work remained to complete the recommendations contained in the "Final Report of the International Joint Commission on the Pollution of Boundary Waters Reference" dated 1918. During this same 35 year period, important changes took place on the Niagara Frontier. Major industrial expansion accompanied by a rapid increase in population contributed adversely to the pollution problem. Dredging operations on Strawberry Island in the upper Niagara River were resumed in 1947. This created an interest in the possible effect on river currents with consequent dispersion of polluted water. This concern, combined with the increase in population and industrial development, precipitated a request for a further study of these boundary waters.

Authorization of Survey

The Governments of the United States and Canada in April 1946 requested the International Joint Commission to investigate pollution of the boundary waters from Lake Superior to Lake Erie with respect to treaty obligations. The original terms of reference of the two Governments were amended April 2, 1948 to include the Lake Erie-Lake Ontario Section as follows:

> "I have the honour to advise you that the Governments of the United States and Canada have been informed that the waters of the Niagara River from Lake Erie to Lake Ontario are being polluted by sewage and industrial wastes emptied into these waters. Having in mind the provisions of Article IV of the Boundary Waters Treaty signed January 11, 1909, that boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on

the other side, and the two Governments have agreed upon a joint Reference of the matter to the International Joint Commission, pursuant to the provisions of Article IX of said Treaty. The Commission is requested to inquire into and to report to the two Governments upon the following questions:

(1) Are the waters referred to in the preceding paragraph, or any of them, actually being polluted on either side of the boundary to the injury of health or property on the other side of the boundary?

(2) If the foregoing question is answered in the affirmative, to what extent, by what causes, and in what localities is such pollution taking place?

(3) If the Commission should find that pollution of the character just referred to is taking place, what measures for remedying the situation would, in its judgment, be most practicable from the economic, sanitary and other points of view?

(4) If the Commission should find that the construction or maintenance of remedial or preventative works is necessary to render the waters sanitary and suitable for domestic and other uses, it should indicate the nature, location and extent of such works, and the probable cost thereof, and by whom and in what proportions such cost should be borne.

"For the purpose of assisting the Commission in making the investigation and recommendations provided for in this Reference, the two Governments will, upon request, make available to the Commission the service of engineers and other specifically qualified personnel of their Governmental agencies, and such information and technical data as may have been acquired by them during the course of the investigation.

"The Commission should submit its report and recommendations to the two Governments as soon as practicable."

Board of Technical Advisers

In accordance with the terms of reference, the International Joint Commission appointed a board of sanitary experts to act as technical advisers to the Commission. The Board consisted of eight members, two from the Federal services of the United States, two from the Federal services of Canada, two from State services of New York, and two from the Provincial services of Ontario.

The members of the Board were:

For the United States

L. M. Fisher, Sanitary Engineer Director, U. S. Public Health Service, Washington D. C. Later succeeded by L. F. Warrick, Senior Sanitary Engineer, U. S. Public Health Service

M. LeBosquet, Jr., Sanitary Engineer Director, U. S. Public Health Service, Cincinnati, Ohio

For Canada

J. Ross Menzies, Chief, Public Health Engineering Division, Department of National Health and Welfare, Ottawa, Ontario

W. R. Edmonds, Senior Sanitary Engineer, Public Health Engineering Division, Department of National Health and Welfare, Ottawa, Ontario

For New York

Earl Devendorf, Director, Bureau of Environmental Sanitation, New York State Department of Health, Albany, New York

C. R. Cox, Chief, Water Supply Section, Bureau of Environmental Sanitation, New York State Department of Health, Albany, New York

For Ontario

A. E. Berry, Director, Division of Sanitary Engineering, Ontario Department of Health, Toronto, Ontario

A. V. DeLaporte, Chemical Engineer, in charge of Experimental Station, Ontario Department of Health, Toronto, Ontario

The joint chairmen of the Board of Technical Advisers were L. M. Fisher (later L. F. Warrick), whose duty it was to preside over meetings of the Board in the United States, and J. Ross Menzies, who presided over meetings in Canada. The two chairmen also acted jointly as liaison officers between the Board and the Commission.

A subcommittee to aid the Board of Technical Advisers, in a study of the effect on the Niagara River of dredging on Strawberry Island, was also appointed by the Commission. Colonel Herbert D. Vogel, U. S. Corps of Engineers, District Engineer, Buffalo, New York, and Mr. C. G. Cline, Senior Assistant Engineer, Water & Power Bureau, Department of Mines and Resources of Canada, Niagara Falls, Ontario, served on this subcommittee.

The Board of Technical Advisers was given the authority to enlist the cooperation of technical officers of other Federal, Provincial, or State Departments or agencies in the United States and Canada; to employ such technical and clerical assistance, to acquire such equipment, and to make such expenditures for travel, as were found necessary.

Organization For Lake Erie-Lake Ontario Investigation

Field work on the survey of the Lake Erie-Lake Ontario section of the boundary waters was initiated in July, 1948. The personnel for this study was supplied by the U. S. Public Health Service, the Department of National Health and Welfare, the New York State Department of Health and the Ontario Department of Health. The field work on the United States side was under the direction of Hayes H. Black, later succeeded by Roscoe H. Goeke, both Sanitary Engineers of the U. S. Public Health Service, and on the Canadian side under A. V. DeLaporte.

General Procedure

The Board of Technical Advisers organized the field work, assigning it to the United States and the Canadian field staffs. Each field staff undertook to examine the boundary waters and to further determine the sources and extent of pollution on its own side. Laboratories were established in St. Catharines, Ontario, and Fort Niagara, New York. The field laboratory at Fort Niagara was subsequently moved to Niagara Falls, New York. The laboratories of the Ontario Department of Health at Toronto, Ontario, the New York State Department of Health at Albany, New York, and the U. S. Public Health Service at Cincinnati, Ohio were utilized for certain examinations in connection with industrial waste surveys. Field studies included sampling of the boundary waters and tributaries, float tests for direction of currents, visual examination of the waters, and investigation of industries and other sources of pollution.

Selection and Designation of Sampling Points

Sampling points for this investigation were selected with due regard to such factors as the location of known pollution sources, the characteristics of the stream flows, and the location of points used during the 1913 survey. These known pollution sources included municipal and industrial sewer outlets along the shores of these waters and tributary streams. Stream flow characteristics were considered significant in that they tend to influence the dispersion of pollution throughout these boundary waters. Since comparison of results with those of the 1913 survey was desired, several of the original sampling ranges were again used.

A mileage index system was used in the present investigation to identify the location of sampling ranges, municipal water intakes, and other important points on the river and its tributaries. This system involved the use of one or more letters to identify the stream or streams, followed by a number which represented the distance in river miles from the mouth or other reference point. The zero mileage point for the Niagara River was taken one mile from the mouth of the river in Lake Ontario at a bell buoy (B-1) established by the U. S. Coast Guard. Distances from this zero point were measured via the East Channel around Grand Island. On the tributaries, the letter Ni, designating the main stream, was retained and another letter or letters added to designate a specific tributary. The mileage index figures used on the tributaries represent the distance from the same zero reference point as used on the Niagara River.

The letters used in designating the various streams, with the distances above the zero reference point are given in table N-1.

TABLE N-1—TRIBUTARY DESIGNATIONS WITH MILEAGES FROM ZERO REFERENCE POINT

Watercourse	Designation	Mileage at Mouth from Zero Reference
Lower Niagara River	Ni	....
Power Canal	Ni PC	9.0
Whitty's Creek	Ni Wt	11.4
Upper Niagara River	Ni	....
Cayuga Creek	Ni Ca	21.0
Black Creek	Ni Bl	24.3
Tonawanda Creek	Ni To	26.4
Ellicott Creek	Ni To Et	26.5
Two Mile Creek	Ni TM	27.2
Frenchmans Creek	Ni Fr	32.8
Black Rock Canal	Ni BR	34.0
Buffalo River	Ni Bu	37.8
Cazenovia Creek	Ni Bu Cz	43.4

The river mileage index system was not adaptable for lake sampling points. On Lake Ontario, a system of radial ranges was used with the reference point located at the same bell buoy, B-1, as used for the river mileages. Two sampling ranges were established in Lake Erie extending from the United States to Canada. Short ranges were given letter designations and were established parallel with or normal to shore.

Laboratory Determinations on River and Lake Samples

Routine determination included coliforms, phenols, chlorides, ammonia, chlorine demand, hydrogen ion concentration (pH), alkalinity, turbidity, temperature, dissolved oxygen, and biochemical oxygen demand. Additional tests were made when abnormal conditions of the river were noted, and when special studies were being conducted.

In general, the analytical procedures followed were those contained in "Standard Methods for Water Analysis", 9th Edition. Specific techniques were utilized where an accepted method was not available, where the standard test for a specific compound was not sensitive enough for the high dilutions encountered, or where other substances caused interference. Such special procedures were used for oils, phenols, cyanides, and tastes, and were the same as those developed for the Lake Superior-Lake Erie investigations.

Possible variations in techniques between the laboratories of the two field staffs were minimized. The same specific batches of laboratory media were used for all bacteriological tests conducted in both laboratories. Checks on analytical procedures were made by occasionally dividing samples between laboratories.

The number of lake and river samples collected totaled 7,778, on which 27,593 examinations were made during this investigation as presented in table N-2. These figures do not include analytical work associated with municipal and industrial plants.

TABLE N-2—LAKE AND RIVER SAMPLES COLLECTED AND ANALYSES MADE

Area or Source	Bacteriological Examinations	Plankton Determinations	Chemical Examinations	
			Samples	Determinations
Lake Ontario	780	2	380	2,915
Lower Niagara River	656	13	496	3,318
Upper Niagara River	1,931	67	1,559	10,272
Lake Erie	621	2	512	3,907
Tributaries	413	14	332	2,682
Totals	4,401	98	3,279	23,094

Chapter N-III

GENERAL DESCRIPTION

"A river is the coziest of friends;
you must love it and live with it
before you can know it."
—C. W. Curtiss, Lotus Eating

The Lake Erie-Lake Ontario Section comprises the eastern end of Lake Erie, the Niagara River with its tributaries, and a portion of Lake Ontario in the vicinity of the outlet of the Niagara River. The land drained by this Section has an area of about 1,836 square miles or 0.62% of the total drainage area of the Great Lakes System. The area under investigation is shown in figure N-1. Physical characteristics and other features are described herein.

Lake Erie — East End

That portion of the east end of Lake Erie which is included in the Lake Erie-Lake Ontario Section embraces an area within a radius of about 10 miles from Buffalo. Lake Erie is a relatively shallow basin, with a mean depth of 90 feet. The 30-foot contour is uniformly about a mile offshore. The lake bottom, on both the United States and Canadian sides, gently slopes with a maximum depth of 60 feet in the 10-mile radius under study. Two small tributaries on the United States side empty into Lake Erie: Smoke Creek, with a tributary area of 33 square miles, and Rush Creek, with a drainage area of 11 square miles. The Canadian side has two small streams, with a drainage area of 18 square miles, that enter the eastern end of the lake.

Lake Erie is the most tempestuous of the Great Lakes because of its position in relation to storm tracks, and its shallow depth. It is subject to sudden storms which cause the lake level to fluctuate widely. At Buffalo, with a continuing east wind, the level drops below the Low Water Datum (L.W.D.) of 570.05 feet, making it impossible, at times, for ships to pass into the harbor. On one occasion the rock bottom at Fort Erie was exposed. Similarly, a continuing southwest wind has raised the level in the harbor as much as 11 feet above L.W.D. The lake freezes late and thaws early, but shipping is normally confined to 7 months of the year.

A dumping area for dredged materials has been designated on the United States side. This area is 0.7 mile wide and extends from shore 1.4 miles into the lake in the vicinity of the mouth of Smokes Creek. The southerly limit approximately parallels the water intake line of the Western New York Water Company, the intake crib being 750 feet distant.

The Niagara River

The Niagara River flows in a northerly direction from the eastern end of Lake Erie to Lake Ontario. It has a total catchment area of 265,095 square miles above Niagara Falls. The river itself drains an area of 1,688 square miles, of which 1,225 are in the United States and 463 in Canada. The stream is about 37 miles long, and divided by Niagara Falls about midway in its length into upper and lower parts.

The Niagara River leaves Lake Erie through a funnel-shaped entrance which narrows in a distance of about 1½ miles to a constricted channel in rock with a minimum width of 1,500 feet and an average depth of about 17 feet where current velocities as great as 10 miles per hour occur. Navigation past these rapids is made possible by the Black Rock Canal which parallels the river for 3½ miles on the United States side. Water levels in this canal are controlled by locks at the northern end of Squaw Island.

The upper Niagara River contains a number of small islands and is divided into two main channels by Strawberry Island and Grand Island. The International Boundary follows the West or Chippawa Channel. This channel, used only by small craft, varies in width from 2,000 to 4,000 feet, and has depths from 15 to 30 feet. The West Channel divides at Navy Island and then combines with the eastern branch to form the large body of water upstream from the rapids above the Horseshoe and American Falls.

The East or Tonawanda Channel commences at Strawberry Island, immediately upstream from the southern tip of Grand Island. A dredged channel 21 feet deep lies east of Strawberry Island from the Black Rock Canal to a point opposite Motor Island. From Motor Island to Tonawanda Island there is a natural average depth of 20 to 28 feet. The balance of the East Channel is comparatively shallow, with widths in this branch varying from 1,600 to 4,000 feet. A channel 12 feet deep for vessel navigation is maintained through the lower 8½ miles of the east branch to Niagara Falls, New York. Dredged material is dumped in an area approximately 900 feet square in the East Channel of the Niagara River between the northerly shore

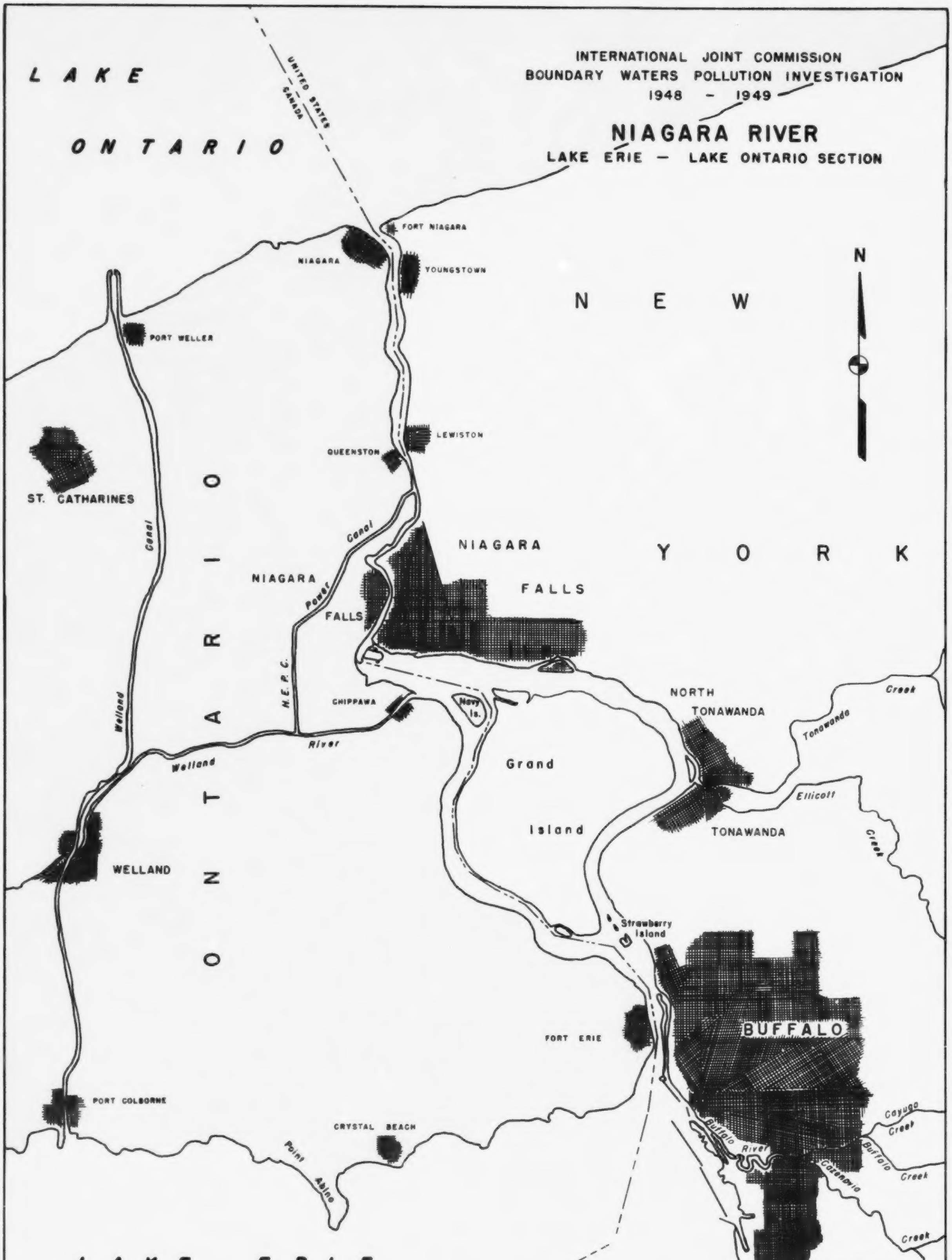

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 - 1949
NIAGARA RIVER
LAKE ERIE — LAKE ONTARIO SECTION
LAKE ONTARIO
UNITED STATES
CANADA
FORT NIAGARA
NIAGARA
YOUNGSTOWN
PORT WELLER
NEW YORK
N
LEWISTON
QUEENSTON
ST. CATHARINES
ONTARIO
Welland Canal
H.E.P.C. Power Canal
NIAGARA FALLS
NIAGARA FALLS
CHIPPAWA
Navy Is.
NORTH TONAWANDA
Tonawanda Creek
Welland River
Grand Island
Ellicott Creek
TONAWANDA
WELLAND
Strawberry Island
BUFFALO
FORT ERIE
PORT COLBORNE
CRYSTAL BEACH
Point Abino
Buffalo River
Cayuga Creek
Buffalo Creek
Cazenovia Creek
Creek
LAKE ERIE
LACKAWANNA
STATUTE MILES
5 0 5 10 15 20
CANADA
UNITED STATES

Figure N-1

229-a

of Buckhorn Island and the channel in the east branch.

Goat Island, a small island at the brink of the Falls, divides it into two separate cataracts, namely the American and the Horseshoe Falls. In 1944 a submerged weir was constructed at right angles to the Canadian shore, upstream from the end of Goat Island, to divert a larger flow of water over the American Falls.

The lower river flows through 6.8 miles of deep gorge from the Falls to the edge of the Niagara Escarpment at Queenston and Lewiston. At the base of the falls, the water flows quietly in a deep channel before entering the narrow shallow channel of the Whirlpool Rapids. The fall in these rapids is about 50 feet in a little more than a mile, with estimated velocities up to 30 miles per hour. The Whirlpool is a circular basin in which the river direction turns nearly 90°. Under normal stages, the incoming water enters the Whirlpool on the top, encircles the basin many times and leaves beneath the inflowing water. Downstream from the Whirlpool the Lower Rapids have a fall of about 40 feet in 2 miles. For the remaining 7 miles from Lewiston to Lake Ontario, the stream widens to an average of 2,000 feet, with an average depth of about 40 feet. This quiescent part of the river is used by some lake vessels.

From a water level of 570.5 feet (L.W.D.) in Lake Erie, the upper river descends to an elevation of 562 feet at the beginning of the rapids just prior to the Falls. A further drop of 54 feet takes place in the rapids approaching the American and Horseshoe Falls, which in turn have a mean drop of about 164 feet. The lower river, at elevation 344 feet at the base of the Falls, drops through the gorge and rapids to approximately Lake Ontario level of 244 feet opposite Lewiston and Queenston. The total drop from Lake Erie to Lake Ontario is about 326 feet.

Niagara River Tributaries

The principal tributaries flowing into the Niagara River are the Buffalo River, Ellicott Creek and the Tonawanda (Barge Canal) Creek on the United States side, and the Ontario Hydro Electric Power Commission's power canal, carrying the Welland River and discharging at Queenston, Ontario on the Canadian side.

The Buffalo River, with its tributary streams of Cazenovia, Buffalo, and Cayuga Creeks, has a watershed of about 424 square miles or 35 percent of the area draining into the Niagara River from the United States side. From its source about 3 miles north of the Village of Arcade in Wyoming County, it flows in a meandering northwest direction to its mouth in the Buffalo Outer Harbor.

The largest drainage area on the United States side is that of Tonawanda Creek, with a watershed of 530 square miles or 43% of the total on the United States side. Its headwaters also start a few miles north of the Village of Arcade, and the stream flows north through Batavia and then in a westerly direction to its mouth on the Niagara River at Tonawanda. The Erie Barge Canal was built in 1825 across upper New York State as an inland waterway to the Hudson River and thence to the Atlantic Ocean. The canal connected into Tonawanda Creek at the hamlet of Pendleton, and that portion of the creek from Pendleton to the river became part of the Erie Canal. With this change, the flow of this portion of Tonawanda Creek was reversed under normal stream flows easterly through the Erie Canal. During periods of heavy run-off however, the flow may be into the Niagara River. In 1918, the canal was deepened and widened and the name changed to the New York State Barge Canal or simply Barge Canal.

Ellicott Creek, with a watershed of 119 square miles, is actually a tributary of Tonawanda Creek although their confluence is less than a half mile from the Niagara River. Its flow may therefore be easterly through the Barge Canal, or into the Niagara River, depending on the flow of water in Tonawanda Creek.

Two other small streams discharge into the Niagara River on the United States side. Scajaquada Creek, with a drainage area of 22 square miles, discharges into the river at Buffalo, and Cayuga Creek, with an area of 34 square miles, discharges at Niagara Falls.

There are no Canadian tributaries of consequence above the Falls. The Welland River and power canal, with a watershed of 375 square miles, represent over 80% of the Canadian tributary area and drain into the Niagara River below the Falls. From its source about 5 miles southwest of Hamilton, the stream meanders through four counties for a distance of 70 miles, although the east-west length of the basin is approximately 46 miles. It drops about 240 feet from the source to its former mouth above Niagara Falls at Chippawa. When the power canal was constructed the flow in nearly 4 miles of the Welland River was reversed, so that water from the upper Niagara River and the Welland River proper is discharged to the lower river at a point 7.7 miles below Chippawa.

Black Creek, another small tributary on the Canadian side with a drainage area of 37 square miles, discharges to the upper river.

A tabulation of the principal watersheds tributary to the Niagara River is given in table N-3.

TABLE IN-3—PRINCIPAL DRAINAGE AREAS TRIBUTARY TO NIAGARA RIVER

Stream	Drainage Areas in Square Miles		
	United States	Canada	Total
Buffalo River......	424	....	424
Scajaquada Creek..	22	....	22
Tonawanda Creek (Barge Canal)...	530	....	530
Ellicott Creek.....	119	....	119
Black Creek.......	....	37	37
Cayuga Creek.....	34	....	34
Welland River.....	....	375	375
Miscellaneous Upper River Areas..	77	33	110
Miscellaneuos Lower River Areas...........	19	18	37
Total......	1,225	463	1,688

Lake Ontario-Niagara River Outlet

That portion of Lake Ontario, included in the Lake Erie-Lake Ontario Section, comprises an area within a radius of about 12 miles from the outlet of the Niagara River. Several small creeks, including Four Mile and Six Mile Creeks with a drainage area of 33 square miles, discharge directly to Lake Ontario on the United States side. In Canada, Two Mile, Four Mile, and Eight Mile Creeks, with drainage area of 44 square miles, flow into Lake Ontario.

Lake Ontario is a very deep lake with depths ranging from 500 feet to a maximum of 778 feet. In the area under study the depths reach 300 feet. At the outlet of the Niagara River, the Niagara Bar and the Rumsey Shoal extend a distance of 3 miles into the lake, with water depths ranging from 9 to 20 feet. There has been no dredging for navigation purposes in the lower Niagara River or in Lake Ontario at the outlet of the river since 1911. Fine sand from the Niagara Bar is dredged for commercial sale.

The surface of the lake is 248 feet above sea level, making two-thirds of the depth below sea level. A surface current usually moves easterly at a rate of about 8 miles per day, with the strongest current along the southern shore. Unlike Lake Erie, heavy waves are slow to rise and to subside. Lake Ontario freezes only near shore, but its harbors are closed about 5 months in the year.

Topography

The Lake Erie-Lake Ontario Section is included in the region comprising central and western New York, western Ontario, and northern Pennsylvania. Viewed broadly, the region consists of a series of terraces or plains descending northward to Lake Ontario and separated by three northward facing escarpments. These escarpments owe their origin and preservation to the fact that they are composed of soft, easily eroded shales below, capped by hard and more resistant limestones and dolomites.

The Portage Escarpment south of the Lake Erie-Lake Ontario Section forms the southern boundary of the Erie plain. This includes the southern part of the triangular Ontario peninsula between Lake Erie and Lake Huron, and a narrow strip along the south shore of Lake Erie. This escarpment extends from Ohio, where it is low and broken by broad valleys, and continues across northwestern Pennsylvania into southwestern New York, where it is abrupt and nearly straight. From Cattaraugus Creek in New York State and extending east, the Portage Escarpment is less abrupt and is broken by deep narrow valleys. East of Auburn, New York, it merges into the Onondaga Escarpment.

The Onondaga Escarpment bounds the Erie plain on the north and separates it from the Huron plain. This escarpment crosses the Lake Erie-Lake Ontario Section in an east-west direction. It is less evident at Buffalo but becomes more prominent east of the city. Across Ontario it is obscured by glacial drift. The Huron plain includes a strip of western New York, the northern part of the triangular peninsula of Ontario and a part of the bed of Lake Huron. Its surface is nearly level and lies about 600 feet above sea level.

Similarly, the Niagara Escarpment crosses the Lake Erie-Lake Ontario Section, separating the Huron and Ontario plains. The Ontario plain includes the shallow basin of Georgian Bay, part of the Province of Ontario between this Bay and Lake Ontario, part of the bed of the Lake, and a strip on the south and west sides of Lake Ontario in New York State. The surface of this plain is irregular, although nearly level in some areas. The Niagara Escarpment can be traced from western New York to northern Illinois. At Rochester, New York, it is about 100 feet high and at Lewiston about 200 feet. At Hamilton, Ontario, it turns northwest and extends to Georgian Bay where it reaches a height of 800 feet. It continues across the northern end of Lake Michigan, reappears in the Green Bay peninsula in Wisconsin, and crosses southwest into Illinois, where it dies out.

The drainage areas of the Niagara River have been established by these escarpments. Three distinct drainage basins in Ontario run parallel for many miles, although the terrain is gently rolling and without high ridges. In New York State there are two main drainage areas, Tonawanda Creek and Buffalo River.

Geology

During the Pleistocene Epoch four glacial ice invasions entered the Mississippi basin. These glaciers carried quantities of boulders, sand and clay. When the ice melted, the surface everywhere was covered with accumulations of glacial drift. In the Lake Erie-Lake Ontario Section, the drift is comparatively thin, from 2 to 150 feet, and the surface appears quite flat, reflecting in a measure the structure of the underlying rock.

Distinct geological formations occur in belts running almost east and west and divided by the three escarpments. The bed rock of the Erie, Huron, and Ontario plains, except for a few small igneous dikes, are wholly sedimentary, laid down during the late Ordovician, Silurian, and Devonian periods of the Paleozoic Era. These consist principally of shales, limestones, sandstones, dolomites, and gypsum. In western New York and north of Lake Ontario the beds have a general east-west trend and a south dip.

The Portage Escarpment is formed by sandstones and sandy shales of the late Devonian Age, having a total thickness of 3,000 feet or more. The Huron plain is occupied by late Silurian shales and sandstones. The Onondaga Escarpment is formed from Onondaga limestone of the middle Devonian Age. Middle Devonian shales and limestones occupy the Erie plain.

The Niagara Escarpment is capped by limestone of the Niagara group, middle Silurian Age. It is this escarpment that the waters of the Niagara River have cut back to form the gorge below Niagara Falls as it is today. The greater part of the Ontario plain is occupied by lower Ordovician strata, chiefly limestone. The remainder, comprising the bed of the southern portion of Lake Ontario and extending along the south side of the lake and thence to Georgian Bay, is late Ordovician limestone and early Silurian sandstone and shale.

Climate

The climate of the Lake Erie-Lake Ontario Section is subjected to many variations caused by storms in the Great Lakes area, but extremes of temperature are moderated by the large water surfaces to the north and south. Buffalo, in particular, is subject to the storms that sweep in from Lake Erie. Sub-zero temperatures occur occasionally during the winter months, but the average and extreme low temperatures inland are similar to those recorded on the shore of either lake. The area is free from tornadoes, earthquakes, and floods.

The east end of Lake Erie, some quiet portions of the Niagara River, and Lake Ontario along its shore, freeze over during the colder months. Ice jams occur in the Niagara River, particularly in the vicinity of Strawberry Island and the south end of Grand Island. These jams affect the flow in the river. Almost yearly, ice floes from Lake Erie and the Niagara River accumulates in the pool below the Falls. Mist arising from the Falls freezes the ice cakes together, forming a so-called "ice bridge." In 1909, an unusual amount of ice accumulated to form a bridge, which reached a height about 40 feet above normal water level. Also noteworthy was the jam of 1938 which damaged power plants located in the gorge and which destroyed the Falls View Arch Bridge by raising it off its abutments located 20 feet above the normal water level. During the winter of 1935-36, the low water level in the Great Lakes combined with sub-freezing temperatures to form an ice barrier between the south end of Goat Island and the

TABLE N-4—CLIMATOLOGICAL DATA FOR SELECTED STATIONS

From Period of Record to 1947, Inclusive

Station	Temperature—Degrees F.				Precipitation—Inches				Wind		
	Years of Record	Annual Average	Maximum	Minimum	Years of Record	Annual Average	Maximum Annual	Minimum Annual	Years of Record	Average Velocity M. P. H.	Prevailing Direction
UNITED STATES											
Derby, New York	3	48.1	98	— 4	3	39.31	43.33	30.44	3	....	SW
Buffalo, New York	75	46.8	99	—20	78	36.00	60.24	22.16	78	14.5	SW
Lockport, New York	48	47.1	103	—24	62	31.08	46.48	17.57	55	....	SW
Lewiston, New York	13	48.6	107	—11	26	25.67	39.53	17.64	13	....	SW
Wilson, New York	0	....	....	....	6	33.14	40.80	25.74	6	....	SW
CANADIAN											
Port Dover, Ontario	33	46	104	—28	33	35.21	....	....	....	....	....
Welland, Ontario	45	47	100	—24	45	33.88	....	....	....	....	....
Vineland, Ontario	12	48	103	—14	12	20.00	....	....	13	9.5	W
St. Catharines, Ontario	21	48	104	—12	21	27.03	....	....	....	....	....
Toronto, Ontario	105	45	105	—26	105	32.18	....	....	23	11.4	SW

TABLE N-5—DISTRIBUTION OF POPULATION BY DRAINAGE BASINS, 1940-41 AND 1949

Drainage Basin	New York			Ontario			Combined		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
1940-41									
Lake Erie	13,100	27,680	40,780	1,250	620	1,870	14,350	28,300	42,650
Upper Niagara River	116,280	675,710	791,990	4,670	6,600	11,270	120,950	682,310	803,260
Lower Niagara River	2,260	79,310	81,570	24,350	34,470	58,820	26,610	113,780	140,390
Lake Ontario	3,320	....	3,320	5,570	1,540	7,110	8,890	1,540	10,430
Totals	134,960	782,700	917,660	35,840	43,230	79,070	170,800	825,930	996,730
1949 (Estimate)									
Lake Erie	16,300	32,700	49,000	1,200	1,300	2,500	17,500	34,000	51,500
Upper Niagara River	144,700	738,500	883,200	4,700	7,500	12,200	149,400	746,000	895,400
Lower Niagara River	2,600	93,500	96,100	29,800	39,600	69,400	32,400	133,100	165,500
Lake Ontario	3,900	....	3,900	6,700	1,700	8,400	10,600	1,700	12,300
Totals	167,500	864,700	1,032,200	42,400	50,100	92,500	209,900	914,800	1,124,700

United States bank of the Niagara River, completely drying the American Falls.

Records of weather stations in the area show considerable variations in precipitation. Heavy rains occur frequently. The maximum recorded intensity has been 4.3 inches per 24 hours. Snowstorms are frequent during the winter months. The Buffalo area has had annual cumulative snow falls as great as 10 feet. Inland, the snowfall is less, and the ground may be bare for part of the winter. Prevailing winds are from the west and southwest with average velocities between 10-15 miles per hour. Infrequently wind storms from the north or east are noted. The highest recorded velocity in the area is 91 miles per hour.

Climatological data on temperature, precipitation, and wind for selected stations are given in table N-4 (see preceding page).

Population

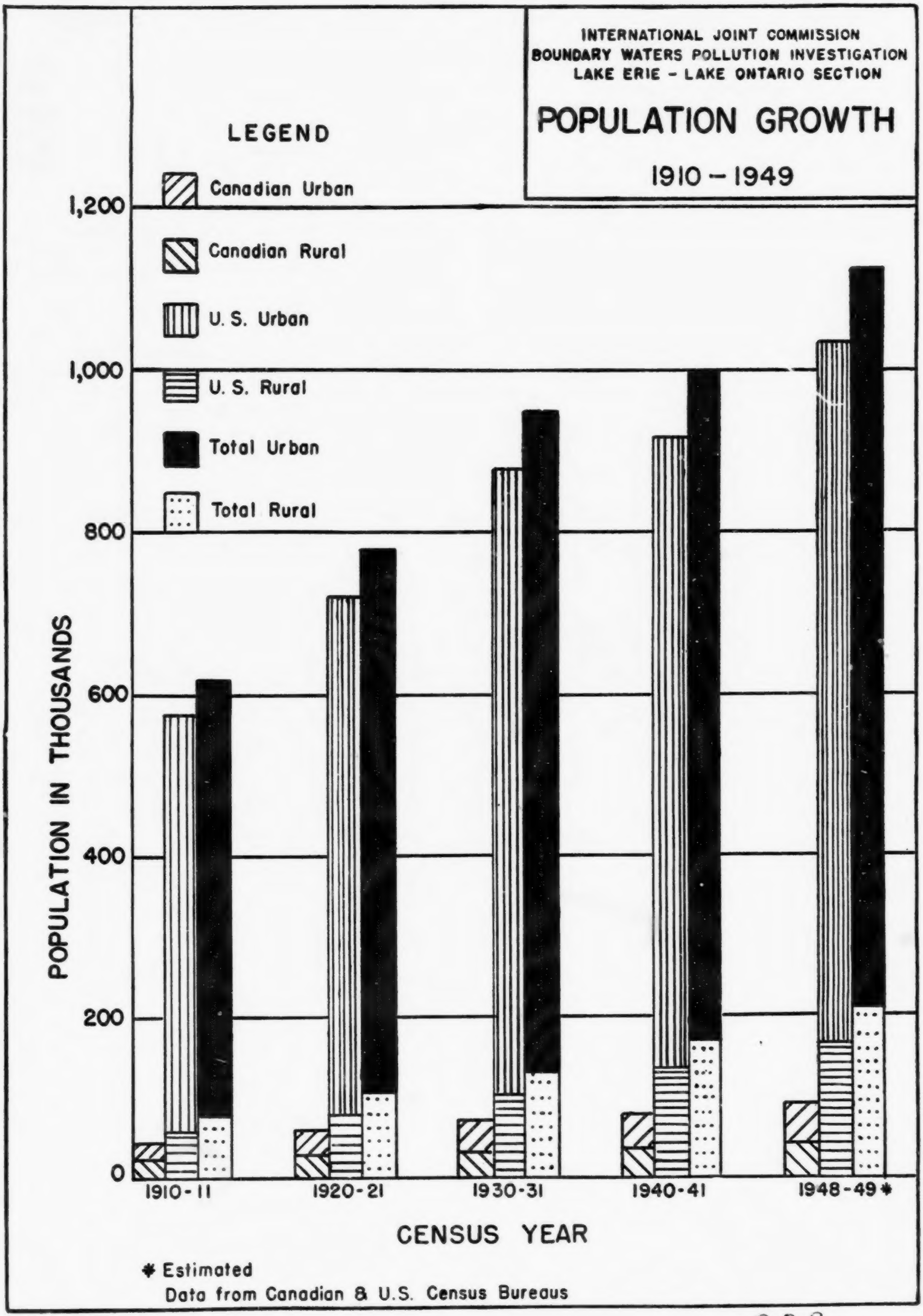
The population in the Lake Erie-Lake Ontario Section approximated 997,000 persons, based on estimates from the data in the 1940-41 census. Recent estimates (1949) indicate an increase of population to about 1,125,000 persons, most of which has occurred in the urban areas. The 1949 population is described as 19% rural and 81% urban. Municipalities having a population under 1,000 were classified as rural. Figure N-2 shows the growth of population from 1910 to 1949.

About 70% of this population lives on the United States side of the upper Niagara River in the intensely developed zone from Buffalo to Niagara Falls. In contrast, the Canadian side is largely parkway and rural area. The distribution of population by drainage basins for the entire area is shown in table N-5, and the population increase for principal municipalities is shown in table N-6. The number of persons per square mile in this area based on 1949 estimates, was about 850 for New York, 200 for Ontario, and 670 for the entire Section.

The Tonawanda-Ellicott Creek drainage basin, included in the Lake Erie-Lake Ontario Section is tributary to the New York State Barge Canal. The Barge Canal drains easterly from the Niagara

TABLE N-6—POPULATION CHANGES IN PRINCIPAL MUNICIPALITIES

Municipality	1910-1911	1920-1921	1930-1931	1940-1941	1949 (Estimated)
Lake Erie-Lake Ontario Basin	615,700	779,600	946,800	996,700	1,124,700
United States Side:					
Lackawanna, New York	14,549	17,918	23,948	24,058	30,000
Buffalo, New York	423,715	506,775	573,076	575,901	617,900
Kenmore, New York	1,020	3,160	16,482	18,612	21,000
Tonawanda, New York	8,290	10,068	12,681	13,008	15,000
North Tonawanda, New York	11,995	15,482	19,019	20,254	27,000
Niagara Falls, New York	30,445	50,760	75,460	78,029	92,000
Batavia, New York	11,613	13,541	17,375	17,267	20,000
Canadian Side:					
Fort Erie, Ontario	1,146	1,546	2,383	6,595	7,500
Niagara Falls, Ontario	9,248	14,764	19,046	20,589	21,700
Welland, Ontario	5,318	8,654	10,709	12,500	16,000


INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
LAKE ERIE - LAKE ONTARIO SECTION
POPULATION GROWTH
1910 - 1949
LEGEND
Canadian Urban
Canadian Rural
U. S. Urban
U. S. Rural
Total Urban
Total Rural
POPULATION IN THOUSANDS
1,200
1,000
800
600
400
200
0
1910-11
1920-21
1930-31
1940-41
1948-49 *
CENSUS YEAR
* Estimated
Data from Canadian & U.S. Census Bureaus

River for about 11 months each year, except during periods of excessive run-off. At such times the creeks discharge into the Niagara River. This drainage basin represents an area of about 650 square miles or 40% of the entire Section, and a population (1949 estimate) of about 100,000 persons, or nearly 10% of the entire Section.

Land Use and Development

The Lake Erie-Lake Ontario watershed is used almost entirely for agricultural and industrial purposes. The area adjacent to the Niagara River, especially on the United States side, is utilized for industrial development, while the rest of the Section is devoted to agriculture. Sport fishing in certain areas is enjoyed, but commercial fishing is not extensive. Bathing beaches are located along the lakes, and on Grand Island in the upper Niagara River.

Agriculture in the Ontario area is devoted chiefly to fruit farms, vineyards, and market gardens. In New York the watershed is located predominantly on the Huron plain, with its poorly drained soil, and is used mostly for hay, grain, and pasture. While dairying assumes a prominent place, poultry also is an important source of farm income.

Because of the availability of cheap hydro-electric power on the Niagara River, many industries were attracted early to this region. Industrial development on both sides of the river is marked with such processes as electro-chemical, ferro alloy, abrasive, chlorine and caustic soda, carbide, steel, fertilizer, and pulp and paper. There is also a large production of acids, coke and by-products, dyes and intermediates, cellulose and rayon, organic chemicals, and petroleum products. There has been a rapid growth of these industries in the last 40 years, and particularly marked during the periods of the two World Wars.

Chapter N-IV

HYDROMETRIC DATA

> "Observe always that everything is the result of a change, and get used to thinking that there is nothing Nature loves so well as to change existing forms and to make new ones like them."
>
> —Meditations IV

Hydrometric data on a watercourse are used to evaluate the effects of flow, currents, distribution into channels, and other related factors which may influence stream pollution. The large volumes of lake water in the Lake Erie-Lake Ontario Section, combined with the swift and variable currents of the Niagara River, serve to dilute and transport the incoming wastes. Pollutants which are concentrated at the point of discharge may become greatly diluted in certain areas or may remain concentrated in others. Even diluted wastes may be carried long distances and cause objectionable conditions in the boundary waters. Pollution is generally most significant at its immediate point of discharge. The extent of its subsequent importance will be influenced by the time, volume and route of flow, the degree of turbulence, and other stream characteristics.

A thorough knowledge of lake and river currents is essential in determining transboundary travel of polluted waters.

Sources of Information

The hydrometric data presented in this report were obtained almost entirely from available records and reports of various Governmental agencies. Flow records for the various power diversion installations were obtained from the private companies concerned.

Long term flow records for the Niagara River at Buffalo were furnished by the U. S. Lake Survey. Discharge records at the mouths of tributary streams emptying into the Niagara River were inadequate. The U. S. Geological Survey furnished short term flow records applicable to the Buffalo River and to Tonawanda Creek. No flow measurements for the Canadian tributaries involved in this study could be obtained. Consequently, flow estimates for the Canadian and other United States tributaries were computed from the Buffalo River and Tonawanda Creek records.

Certain information on the course of pollution in both Lake Erie and the Niagara River, particularly in regard to transboundary movement, was obtained from float studies made by the United States field staff.

Flow Characteristics

Information on the flow characteristics and the influencing factors are presented for both the Niagara River and its tributaries.

Niagara River

The average flow of the Niagara River at its inlet from Lake Erie for the 90-year period 1860-1949) was 202,000 cubic feet per second (c.f.s.). Flow velocities increase gradually within the funnel shaped inlet, and approach a maximum velocity of about 15 feet per second (f.p.s.) within the constricted channel in the vicinity of the Peace Bridge.

To facilitate navigation around these rapid currents the Black Rock Canal was constructed adjacent to the river. This canal was completed in 1913, and replaced that part of the Erie Barge Canal connecting Buffalo and Tonawanda. The Black Rock Canal extends northward from the inner harbor of Buffalo to the downstream end of Squaw Island, a distance of 3.5 miles. Flow in the canal is regulated at the Black Rock Locks located at the northern terminus. Data obtained from the Corps of Engineers for 1948 operations show an average flow of about 200 c.f.s. through the canal, indicating the low velocities prevail.

About 4 miles downstream from the river inlet, the channel widens and flow velocities of from 2 to 5 f.p.s. occur. The river is divided at Grand Island into the East (Tonawanda) Channel and the West (Chippawa) Channel. River distances around Grand Island are 13 miles for the East Channel and 9 miles for the West Channel. The flow distribution shows that about 43% of the total follows the east branch and 57% follows the west branch. Velocities in the deeper East Channel average about 2.5 f.p.s., whereas in the West channel averages are about 5 f.p.s.

The east and west branches combine about 4 miles upstream from Niagara Falls to form the headwaters approaching the upper rapids or cascades. The river is divided at the rapids by Goat Island which also separates the American and the Horseshoe Falls. Previous to the construction of a submerged rock-fill weir above the cascades on the Canadian side, flow over the American Falls averaged only about 4.7% of the total flow. Ice jams above Goat Island tended to close off the

American Falls even further, and on one occasion in 1936 the flow was completely stopped. Since completion of the submerged weir in 1944, flow over the American Falls has been increased to about 9% of the total, or an average of about 11,000 c.f.s. Total flow over the Falls, because of water diverted for power uses, is only about 118,000 c.f.s., or 58% of the Niagara River flow at Buffalo.

The lower river below the Falls flows quietly for about two miles in a deep channel from the Maid of the Mist pool to the Whirlpool Rapids. The swiftest velocities in the river occur in these rapids, extending about one mile above the Whirlpool. Velocities as high as 45 f.p.s. (30 miles per hour) have been estimated). The full diluting power of the river is probably first realized within this stretch.

The lower river enters the Whirlpool where the circulating currents complicate the flow pattern. The detention time within the Whirlpool has not been estimated but surface drift material has been known to remain there for days. The two-mile section downstream from the Whirlpool is known as the Lower Rapids. The flow entering this narrow channel discharges to the wider quiescent reaches of the lower river at Lewiston. This final 7-mile length of the river flows sluggishly at an estimated 2 f.p.s. velocity into Lake Ontario.

Factors Influencing Flow Conditions

The rate of flow in the Niagara River is dependent almost entirely upon the water level of Lake Erie at Buffalo. As a consequence, the river is not subject to the wide variations of discharge as are common to most streams affected by seasonal droughts and floods. Nevertheless, due to influencing factors limited periodic and sudden variations do occur. The mean monthly flow figures range from 117,000 tc 253,000 c.f.s.

The most significant factors effecting the discharge rate of the river are those causing long term periodic variations. Of secondary importance are those factors which tend to cause sudden fluctuations in discharge. Ice conditions, tributary inflow, and power and navigation diversion systems cause relatively minor changes in the river discharge. These, nevertheless, effect changes in flow conditions which may in turn alter the pollution distribution within the river. These various influencing conditions are discussed separately.

Long term periodic cycles of the annual mean water levels at Buffalo have a dominating effect upon the river flow. Records indicate these cycles recur irregularly with varying durations of about 10 to 30 years, and have caused a range of mean monthly water level at Buffalo of about 5 feet. These cycles result mainly from corresponding cycles of precipitation in the Great Lakes basin, but are also effected by numerous other meteorological factors. Records show that this variation in lake level has produced a range in the annual mean discharge rate of the river in the order of 75,000 c.f.s. Minor cyclical variations occur annually with seasonal changes, causing somewhat higher flows in the summer than in the winter.

Sudden fluctuations of water level at Buffalo occur, due primarily to winds and changes of barometric pressure. At times of high velocity the prevailing westerly winds have frequently raised the level at Buffalo by several feet. Similarly, easterly winds may lower the lake level at Buffalo. These disturbances may also produce seiches or oscillations of the lake surface which sometimes add several feet to the effect of wind and barometric pressure in changing the water level at Buffalo. Although these conditions have caused a range in stage as great as 15 feet, their duration is usually short. Accordingly, they produce a change in river discharge for only a few hours because of the time lag in transmitting these fluctuations downstream. Generally, they do not alter materially the mean monthly discharges.

Ice conditions along the Niagara River vary from year to year, depending upon the amount and location of ice. Usually the effect on the discharge rate is negligible, but ice stoppages have caused a flow decrease of as much as 20,000 c.f.s. The more extensive of these ice jams are caused by the spring break-up of the Lake Erie ice field. On the upper river ice flows accumulate on reefs above the river inlet, in shoal areas, and in the shallow pools above the upper rapids. These jams tend to produce temporary changes in river currents. The ice bridges which form nearly every year in the Maid of the Mist pool probably have little effect on river flow. Serious ice jams have occurred at the outlet of the lower river causing backwaters to extend as far upstream as the lower rapids.

The flow of tributaries into the Niagara River is relatively insignificant. Consequently, seasonal variation in run-off from them is of minor importance in the total river flow. The average inflow for the entire basin is about 1,340 c.f.s.

Water is diverted from the Niagara River for power, navigation, and domestic and industrial uses. Power diversions use large quantities of water which are subsequently returned to the river, whereas the minor quantity of water used for navigation is not returned to the river. The water diverted for domestic and industrial purposes is relatively small in volume.

Diversions from the river for power generation are limited by joint agreements between United States and Canada. The original authorization by virtue of Article V of the Boundary Waters Treaty of 1909 permitted diversions of 36,000 c.f.s. for Canada and 20,000 c.f.s. for the United States. During World War II subsequent authorizations made possible temporary additional diversions of 18,000 c.f.s. for Canada and 12,500 c.f.s. for the United States. In 1948, a further flow of 2,500 c.f.s. was authorized for Canada to be diverted through the Welland Ship Canal only in the non-navigation season. The total permissible diversion for power is therefore 89,000 c.f.s., 56,500 c.f.s. of this being allocated to Canada and 32,500 c.f.s. to the United States.

The total actual diversion for power purposes averaged about 84,200 c.f.s. or about 42% of the river flow for the 5-year period 1945-1949, with 53,000 c.f.s. being used by Canada and 31,200 c.f.s. by United States. Except for the water diverted for power through the Welland Canal, the entire power diversion is withdrawn from the upper river within 2 miles of Niagara Falls. Approximately 84% of this diversion is returned to the river within or adjacent to the Maid of the Mist pool below the Falls. The remaining 16% is used by the Queenston Plant of the Hydro-Electric Power Commission of Ontario, located about 6 miles below the Falls with its discharge at that point.

A new treaty providing additional diversion for power purposes was signed February 27, 1950 and awaits ratification by both Governments to make it effective. This treaty is intended to safeguard the scenic grandeur of the Falls by maintaining an adequate flow over it and by authorizing construction of control works to ensure an unbroken crestline at the Falls. Flow over the Falls is not to be reduced to less than 100,000 c.f.s. during daylight hours approximately, and 50,000 c.f.s. during darkness, unless additional water is required for flushing of ice in the river. This in effect would reduce the total flow of water over the Falls to an average of about 35% of the flow of the Niagara River at Buffalo. The estimated average flow of water available for power diversion under the new treaty is 131,000 c.f.s., which is to be divided equally between the two countries. Any change in the hydraulic regimen of the river may produce effects which cannot be predicated from present limited information.

Diversion from the river for navigation purposes includes the water used to augment flow in the New York State Barge Canal and that used in the Welland Ship Canal. Although the latter connects Lake Erie to Lake Ontario directly, in effect it reduces the river flow by an amount equal to the canal flow.

For the operation of the Barge Canal, a flow of approximately 1,000 c.f.s. is required during the navigation season which extends usually from April 1 to December 1. The principal source of this water is the Niagara River. Practically the entire flow during dry weather is from the river, and only for one or two days each year is the flow from Tonawanda Creek adequate for canal requirements. During most of the four months when the canal is closed to navigation, somewhat less water passes through, while no water is diverted during a 1-month period when the canal is dewatered for inspection and repairs.

Operating data for the Welland Canal during 1937 and 1948 show an average maximum monthly flow of about 6,000 c.f.s. Probably an average reduction in Niagara River flow of about 2% is produced by this diversion.

Niagara River Tributaries

Basic flow data for Niagara River tributaries are incomplete, as indicated in table N-7. Therefore, flows for the major tributaries were estimated. Except for the Tonawanda Creek discharge, the flows for all tributaries were based on data for the Buffalo River tributaries where most complete records were available. These results are shown in table N-8 (see following page).

The average run-off for the Niagara River drainage basin is about 1.40 c.f.s. per square mile, with 1.37 c.f.s. per square mile on the United States side and 1.45 c.f.s. per square mile on the Canadian side.

It should be noted that flows in the lower reaches of both Tonawanda Creek and the Welland River

TABLE N-7—NIAGARA RIVER AND TRIBUTARY GAGING STATIONS

Stream	Location of Gaging Station	Period of Record	Discharge, c. f. s.		
			Average	Maximum	Minimum
Niagara River	Buffalo, N. Y	1860-1949	202,000	253,000*	117,000*
Buffalo River Tributaries:					
Buffalo Creek	Gardenville, N. Y	1939-1949	191	14,000	0.7
Cayuga Creek	Lancaster, N. Y	1939-1949	126	7,480	0.5
Cazenovia Creek	Ebenezer, N. Y	1941-1949	213	11,200	3.7
Tonawanda Creek	Batavia, N. Y	1944-1948	220	4,600	1.5

*Represents maximum and minimum of monthly mean discharge.

TABLE N-8—ESTIMATED TRIBUTARY DISCHARGES AT CONFLUENCE WITH NIAGARA RIVER

Tributary	Discharge Point	River miles from Niagara River Mouth	Average Discharge c. f. s.—Estimated
United States:			
Cayuga Creek (Niagara Falls)	Niagara River, East Channel	21.0	49
Tonawanda Creek	Niagara River, East Channel	26.4	—151*
Scajaquada Creek	Upper Niagara River	34.4	32
Buffalo River	Buffalo Harbor	37.8	600
Miscellaneous			139
Canada:			
Welland River—HEPC Canal	Lower Niagara River	9.0	543
Black Creek	Upper Niagara River	24.3	54
Miscellaneous			74
Total			1,340

*Negative discharge represents the difference between Barge Canal requirements (1,000 c.f.s.) and average Tonawanda Creek flow (849 c.f.s.).

have been reversed in direction from their natural courses. Tonawanda Creek has been reversed for a distance of about 12 miles from the river, this section serving as the western end of the Barge Canal. The total of 1,000 c.f.s. required for the operation of the Barge Canal is contributed in part from Tonawanda Creek above the hamlet of Pendleton, and Ellicott Creek at Tonawanda, with the remainder being diverted from the Niagara River. Therefore, any flow originating from storm water run-off in the basin above Pendleton in excess of the 1,000 c.f.s. would discharge into the Niagara River. Since during the non-navigation season less water is used in the canal, such flows are more likely to discharge into the Niagara River. The entire flow from both Tonawanda and Ellicott Creeks discharges into the Niagara River for about 1 month each year when sections of the canal are dewatered.

The Welland River has been reversed for a distance of about 4 miles where the Hydro Electric Power Commission's power canal diverts the flow to the Queenston Plant on the lower river. Flow in the power canal is about 14,000 c.f.s. Comparison of this flow with the average Welland River basin inflow of about 540 c.f.s. indicates that the Welland River would not discharge into the upper Niagara River.

The Buffalo River is a navigable channel extending a distance of nearly 6 miles from Buffalo Harbor to the confluence of the Buffalo and Cazenovia Creeks. A depth of about 21 feet is maintained in the river in order to facilitate traffic of lake vessels to the industries. The channel is presently being dredged to depths of 22 and 23 feet in certain sections. The Buffalo River offers an unusual pollution control problem because of the many large industries located along its banks.

The average flow in the Buffalo River for the period of record (1940-1949) is about 600 c.f.s. However, flow during the months of July, August, and September, for the same period of record, averaged about 89 c.f.s. or 59 million U. S. gallons per day (M.G.D.-U.S.). The lowest recorded flow for these months occurred in 1949, when the average river flow was about 57 c.f.s. or 37 M.G.D. (U.S.). These discharge figures include about 10 M.G.D. (U.S.) of water, supplied to industries from the City of Buffalo's municipal water system, which is subsequently discharged into the river. Present industrial demands along the river require about 125 M.G.D. (U.S.). Except for the 10 M.G.D. (U.S.) supplied by the city, this entire industrial consumption is recirculated from the Buffalo River. Thus, during the summer period, the river water is reused by the various industries an average of from two to three times. During these dry periods, therefore, the pollutants in the river become increasingly concentrated. Not only does the river become grossly polluted, but the water is made undesirable for subsequent industrial use. A plan, known as the Lake Erie Cooling Water Project, has been proposed as a means of partially alleviating these conditions. This project provides for pumping from 120 to 180 M.G.D. (U.S.) of water from Lake Erie for industrial use. This water would then be discharged to the Buffalo River, thereby creating a more continuous flow toward the Niagara River.

Variations in the discharge of the Buffalo River present additional pollution hazards. A rising of the lake surface at Buffalo as is commonly caused by prevailing southwesterly winds may prevent any discharge from the river or may even reverse the flow over a considerable distance. Of even greater significance are the sudden high flows from the river caused by either heavy storms on the watershed or by easterly winds lowering the lake surface. In those instances, slugs of pollution from the Buffalo River have been responsible for fish kills, and have had an adverse effect on water supplies downstream on the Niagara River.

Several plans to provide an additional entrance to the Buffalo River from the outer harbor are presently being considered. New pollution problems will be created if any such change is made in the location of the river's discharge into the harbor.

Transboundary Currents

The inter-mixing of waters in the upper Niagara River across the International Boundary is hindered by the high velocity of flow. This results in a striking horizontal stratification of the flowing water. This phenomenon is made visible by differences in the turbidity and color of the water, and has been substantiated by the results of the chemical and bacteriological data.

A study of surface currents in the eastern end of Lake Erie and in the Niagara River was conducted by the United States field staff during the fall of 1949, through the release of some 540 small wooden surface floats at six points located about one-half mile from the Canadian and from the United States shores of Lake Erie. Nearly 400 observations on these floats were reported by residents of both United States and Canada. No method was available, however, for following the course of the various floats from their points of release to the points where they were observed.

Many of the floats placed in Canadian waters were found to remain in coves along the Canadian shore for several weeks, or presumably until the wind direction changed. A few crossed the International Boundary to the United States shore near Wanakah, New York. Some floats placed in United States waters crossed to the Canadian shore, others to the Buffalo Harbor area, and a still greater proportion entered the Niagara River. The influence of the main flow toward the river was observed particularly with floats placed about 4 miles from the river inlet along the Canadian shore.

A study of the currents within the upper Niagara River was attempted, utilizing repeated observations on floats which reached the river inlet. However, due to the lack of continuous observations on single floats, no significant analysis of the flow patterns could be made. For the same reason, although a major portion of the floats observed in the upper river were reported at locations across the boundary from their original release point, it could not be determined whether these floats crossed the boundary within Lake Erie or within the river. In any case, the floats responded to surface currents or to wind action; therefore, these studies are inconclusive as to deeper currents affecting the main body of water. In general, the distribution of reported floats in the east and west branches of the river agrees with a stream flow data that over half of the total flow in the upper river enters the West Channel.

The observations made on floats in the lower river were too limited to be conclusive. It is known that cross-channel mixing together with high turbulence causes a marked transboundary flow of water throughout both the lower rapids and the Whirlpool.

Strawberry Island

Early in 1947 concern was expressed by the New York State Department of Health over the dredging of Strawberry Island, located in the upper Niagara River upstream from the head of Grand Island. The matter was called to the attention of the U. S. Department of State, which in turn referred the question to the International Joint Commission. It was feared that continued dredging of the island would weaken it to the point where it might be removed by natural forces and would change the hydraulic regimen of the Niagara River. This might permit pollution, now following the United States shoreline, to enter the relatively uncontaminated West Channel where it is proposed to locate several water supply intakes.

In the past there has been intermittent dredging in the bed of the Niagara River in the vicinity of Strawberry Island. However, the State of New York passed a statute effective May 23, 1942 prohibiting further dredging in the bed of the upper river. Present dredging of Strawberry Island is being done by a private company under a permit issued by the U. S. Department of Army. It authorizes excavation of material in the interior of the island, specifies the width of berms that must be left around the island, and provides that the company must prevent erosion of the shoreline or the occurrence of any condition that may disturb the hydraulic regimen of the river.

A special subcommittee was appointed by the International Joint Commission to study the question. The subcommittee submitted a report under title of "Report of Special Committees to the Board of Technical Advisers, International Joint Commission, Re: Dredging on Strawberry Island," dated July 23, 1948. This information was supplemented by a report, dated February 1, 1949, prepared by the U. S. field staff.

The special subcommittee report indicates that the presence of Strawberry Island and surrounding shoals help to prevent strong northeast winds from blowing contaminated water from the polluted zone along the United States shore across into the West Channel. While this danger becomes less serious if the pollution along the United States side is diminished, it was agreed that it is of importance that Strawberry Island be maintained as a barrier against the possibility of such an occurence.

Since the shores of Grand Island are clay of geological origin, whereas Strawberry Island consists of sand and gravel apparently deposited by the river itself, the report states that this indicates a tendency to build up the island rather than to wash it away. It was concluded that dredging of the interior of Strawberry Island under conditions specified in the present permit would not alter the currents in the river and thereby would not contribute to the pollution of the water in the West Channel of the Niagara River.

The information submitted by the technical staff contained historical records, dredging permits and records, and maps which supported the subcommittee's conclusion.

The Board of Technical Advisers on February 1, 1949 approved the "Report of Special Committees" and "Information Supplemental to Report," and adopted the following resolution:

"WHEREAS, the International Joint Commission has assigned to the Board of Technical Advisers the task of determining if and to what extent "the continued dredging operations in the Niagara River may result in polluting the waters of the Niagara River (West Channel) in such a way as to endanger the health of citizens of Niagara Falls and other residents of that area.", such dredging operations in question being in the interior of Strawberry Island and being conducted under authority of a permit of the Corps of Engineers, Department of the Army, dated May 5, 1947; and

"WHEREAS, a Subcommittee was appointed by the Commission to assist in the assignment, and said subcommittee has deliberated and has submitted a "Report of Special Committees to the Board of Technical Advisers, International Joint Commission, re: Dredging of Strawberry Island" under date of July 23, 1948; and

"WHEREAS, the United States Technical Staff has submitted "Information Supplemental to Report of Special Committees" dated February 1, 1949, this information having been collected with the assistance of the Canadian Technical Staff, the State Department of Health of New York, the District Engineer, Buffalo District, Corps of Engineers, the U. S. Lake Survey, and others, and such "Information Supplemental to Report" having been presented at the present meeting; and

"WHEREAS, as a result of its examination of the Report of Special Committees and the Information Supplemental to Report, the Board is convinced that all reasonable investigations have been completed; and

"WHEREAS, the Permit dated May 5, 1947, provides "(k) That this authorization covers only the excavation of material in the interior of the said island within the limits as specified on the map attached hereto. (1) That the permittee shall make provisions at his own expense and satisfactory to the said District Engineer to prevent erosion of the shoreline of said island, or the occurrence of any condition that might disturb the hydraulic regimen of said river, and that the construction of such works therefor as the said District Engineer may require shall precede dredging operations or follow such order as he may direct in writing"; and

"WHEREAS, it is the opinion of the Board, concurred in by the New York State representatives on the Board, that the dredging now completed or immediately contemplated under the terms of the Permit dated May 5, 1947, will not have an adverse effect on the waters of the Niagara River west of Grand Island.

"WHEREAS, no further activity is contemplated on the part of the Board, its subcommittee or the United States and Canadian technical staffs in regard to Strawberry Island dredging; and

"NOW, THEREFORE, BE IT RESOLVED, that the report of the subcommittee entitled "Report of Special Committees to the Board of Technical Advisers, International Joint Commission, Re: Dredging on Strawberry Island" dated July 23, 1948, and the "Information Supplemental to Report of Special Committees" presented by the United States Technical Staff and dated February 1, 1949, be approved and that copies of said Report and Information Supplemental to Report be forwarded by the United States and Canadian Board Chairmen to the United States and Canadian members of the Commission."

Chapter N-V

USES OF BOUNDARY WATERS

> "Look beneath the surface let not the several quality of a thing nor its worth escape thee."
>
> —Meditations IV

The pollution of boundary waters is of major significance because of the multiplicity of purposes for which these waters are utilized and the resulting conflict between these uses. Article VIII of the treaty between the United States and Great Britain relating to boundary waters, signed January 11, 1909, states:

> "The following order of precedence shall be observed among the various uses enumerated hereinafter for these waters, and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of precedence:
>
> (1) Uses for domestic and sanitary purposes,
> (2) Uses for navigation, including the services of canals for the purposes of navigation,
> (3) Uses for power and for irrigation purposes."

This order of precedence should be noted in that domestic and sanitary uses, which are so closely related to public health, are given priority over all other purposes. It is also significant that other water needs, such as industrial, recreational, and support of fish and wildlife, which have come into prominence in the intervening years, are not specifically cited in the treaty. It is recognized, and rightly so, that these waters have now come to serve this expanded category of uses. Irrespective of these needs, the treaty requires that boundary waters shall not be polluted on either side to the injury of health or property on the other.

These waters constitute natural resources which have been developed to a high degree by both countries. If these resources are to be conserved for the greatest public benefit, their many and varied usages must be appraised. These are discussed herein.

Domestic Water Supply

Approximately one million persons, residing in some 40 communities, use the connecting waters from Lake Erie to Lake Ontario as a source of domestic water supply. Total water pumpage is

TABLE N-9—MUNICIPAL WATER SUPPLY SOURCES

Municipality	Source	Estimated Population Served 1948-1949	Daily Consumption M. G. D.	Water Treatment
United States:			(U.S. Gal.)	
Wanakah, N. Y.	Lake Erie	5,000	0.35	F, C, TO
Metropolitan Buffalo area served by Western New York Water Company	Lake Erie	150,000	20.0	F, C, TO
Buffalo, N. Y.	Lake Erie	607,200	135.0	F, C
Town of Grand Island, N. Y.	Niagara River, West Channel	400	0.06	F, C, TO
Tonawanda, N. Y.	Niagara River, East Channel	13,000	3.5	F, C, TO
North Tonawanda, N. Y.	Niagara River, East Channel	20,300	6.0	F, C, TO
Lockport, N. Y.	Niagara River, East Channel	28,000	7.0	F, C, TO
Niagara Falls, N. Y.	Niagara River, East Channel	110,000	40.0	F, C, TO
Wilson, N. Y.	Lake Ontario	1,600	0.10	F, C
Total	....	935,500	212.0	F, C
Canada:			(Imp. Gal.)	
Crystal Beach, Ont.	Lake Erie	Winter 1,300	0.40	F, C
		Summer 22,000	1.2	
Fort Erie, Ont.	Upper Niagara River	10,600	1.0	C
Niagara Falls, Ont.	Welland River	37,300	5.5	F, C
Chippawa, Ont.	Niagara Falls Filtered Supply	1,600	0.20	C
Niagara, Ont.	Lower Niagara River	1,900	0.26	F, C, TO
Total	....	52,700	7.4	....

F	Coagulation, Sedimentation, Filtration.
C	Chlorination.
TO	Taste and Odor Control.

about 220 million U. S. (180 million Imperial) gallons per day. Details of major public water supply sources are given in table N-9.

The sources of supply serve all the major communities bordering the boundary waters as well as Lockport, some 20 miles distant. As the water supply of each municipality is affected by pollution introduced upstream, it is of significance that all the municipalities listed in table N-9 have been forced to complete water treatment. It will be noted in most cases that treatment has been augmented by taste and odor control. This is necessary because chlorophenolic tastes and odors occur when these phenol-bearing waters are disinfected with chlorine. More recently treatment with chlorine dioxide has greatly reduced these taste and odor difficulties.

Four major water intakes in the East Channel have been located in the westerly portion of this stream in an effort to avoid the polluted zone along the easterly shore. The location of new intakes in the upper Niagara River also has been influenced by pollution originating in Buffalo and subsquently following the East Channel. An extension of the Niagara Falls, New York, water intake from the east branch to the International Branch of the West Channel at the downstream end of Grand Island is now under way. Similarly, plans are being developed to construct new intakes to serve an extended area to the east of the Niagara River. The sources of supply are likely to be Lake Erie, or the waters of the west branch at the upstream end of Grand Island, rather than the waters of the nearer east branch.

Sanitary Purposes

The major portion of the water pumped for domestic consumption is returned to the boundary waters as sewage, either treated or untreated. This daily sewage flow amounts to about 230 million U. S. (190 million Imperial) gallons from nearly 900,000 persons. Sewer outfalls are widely distributed along the boundary waters and their tributaries, but the major portion of these wastes is discharged from the metropolitan areas of Buffalo, the Tonawandas, Niagara Falls in New York and from Niagara Falls in Ontario.

Navigation

Both passenger and freight vessels navigate the east end of Lake Erie, with freight and small pleasure craft utilizing the Black Rock Canal and the upper Niagara River. The lower Niagara River is used in the quiet portion by one passenger vessel.

To marine interests, Buffalo is becoming known as a shallow port because its ruling depth of 21 feet will not allow ships of greater draft to enter the harbor. There have been increasing difficulties, also, in maneuvering the larger lake vessels within the narrow, winding confines of the Buffalo River. While these factors tend to decrease navigation into the port, the City of Buffalo is contemplating creation of a Port Authority to solve these navigation problems. Additional dredging to depths of 22 and 23 feet is already under way, and several plans have been proposed to reduce the number of bends in the Buffalo River.

The extent of navigation on these waters is reflected by the following figures. During the 1947 navigation season, a total of 15,900 vessel passages were made in and out of the Port of Buffalo, carrying a total cargo of over 20,000,000 tons. The number of crew members on these passages approximated 523,000 persons. In addition, there were about 1,875 recreational craft entering and departing Buffalo Harbor, carrying a total of about 6,600 passengers.

In 1948 a total of over 5,300 vessels passed through the Black Rock Canal and Locks. The net tonnage was in excess of 4,200,000 tons, with crew members on the registered vessels totaling 42,000 persons. This does not include the crew members on over 2,700 unregistered vessels. Passengers carried through the canal were about 7,100 persons.

Many of the vessels passing through the Black Rock Locks continue through the New York State Barge Canal System. During the 1949 navigation season the freight carried by vessels through the canal was estimated at 535,000 tons. This tonnage was carried primarily by tug-towed barges. Crew members on the tugs and barges totaled about 6,500.

One passenger vessel uses the lower Niagara River from Queenston into Lake Ontario and carries about 250,000 persons during a summer season.

The disposal of sewage, refuse, oil, and ballast and bilge water from vessels is important, especially in restricted areas near sources of public water supply or near bathing beaches. It may also affect the potable water supply of other vessels.

Power and Irrigation

The use of the boundary waters for power and irrigation was listed third in the order of precedence in the Treaty of 1909. The treaty limited the daily diversion of water from above Niagara Falls for power development to 56,000 c.f.s.; 20,000 c.f.s. for use on the United States side, and 36,000 for use on the Canadian side.

The first successful development of power from the Falls dates from 1877 when the Niagara Falls Hydraulic Power and Manufacturing Company constructed a canal on the United States side from above the Falls to the edge of the gorge where two power plants were built. Two more plants were constructed on the same site in 1918 and 1921, and these four plants are now known as the Schoellkopf Station of the Niagara Falls Power Company. Just prior to 1900 a second development on the United States side was begun. Two plants were constructed about a mile and one-half above the Falls utilizing a short intake forebay, deep wheelpits for power units, and a long tailrace tunnel which discharged downstream into the Maid of the Mist pool. These plants are known today as the Edward Dean Adams Station of the Niagara Falls Power Company.

Power development on the Canadian side began in 1893 with a small installation by the International Railway Company. Major construction started early in 1900 when the Canadian Niagara Power Company, the Ontario Power Company, and the Electrical Development Company built power plants adjacent to the Falls. The latter two plants are known today as the Ontario and Toronto Plants, respectively, of the Hydro Electric Power Commission of Ontario. The design of the Canadian Niagara Power Company's station and the Toronto Plant are similar to that of the Edward Dean Adams Station, but the third utilizes conduits and penstocks to convey the water to the power generator units which are located on the bank of the Maid of the Mist pool.

The Queenston-Chippawa development was constructed between 1916 and 1921. This development by the Hydro Electric Power Commission of Ontario consisted of intake works at the mouth of the Welland River, reversing the flow in a section of the river, dredging the bed of the river, and construction of a canal from Montrose to Queenston where the power house was located. Thus, the discharge of the Welland River combines with Niagara River water diverted at Chippawa, and the combined flow enters the lower river by way of the power canal. This power plant showed marked advancement over earlier developments and is the only one utilizing the full head available from the river. It is known as the Queenston Plant of the Hydro Electric Power Commission.

The total output of the present power installations on the two sides of Niagara Falls is listed below:

United States	
Niagara Falls Power Company	
Schoellkopf Station	334,800 Kilowatts
Edward Dean Adams Station	80,000 Kilowatts
Canada	
Hydro Electric Power Commission	
Ontario Plant	130,000 Kilowatts
Toronto Plant	110,000 Kilowatts
Queenston Plant	320,000 Kilowatts
Canadian Niagara Power Company	
Wm. B. Rankine Station	74,600 Kilowatts
TOTAL	1,049,400 Kilowatts

Several of the above units were not in use in the 15-year period prior to World War II because water for diversion purposes was not made available. Due to that emergency, however, agreements between the two Governments were made during the course of the war to increase diversion of water from the upper river by 30,500 c.f.s. The United States was to use 12,500 c.f.s. and Canada 18,000 c.f.s. All of the available power units have been in use since that time.

A new treaty providing for diversion of additional water for power purposes, as noted in the previous chapter, now awaits ratification by both Governments. This treaty provides an estimated average diversion of 131,000 c.f.s. to be allocated equally to both countries. Both United States and Canadian power agencies are studying plans for redeveloping power installations to utilize this additional water diversion as well as the full head available at the Falls.

There are no irrigation projects on the Lake Erie-Lake Ontario Section of the boundary waters.

Industrial Uses

Industry uses these waters for process, steam power, cooling, and sanitary purposes. The water so used, exclusive of steam power plants, amounts to nearly 500 million U. S. (420 million Imperial) gallons per day. Of this daily amount, 155 million U. S. gallons are pumped from Lake Erie, 124 million U. S. gallons from the Buffalo River, and about 183 million U. S. gallons from the upper Niagara River. No industries in the area take water from the lower Niagara River or Lake Ontario.

About 60% of this industrial supply is returned directly to the boundary waters, while approximately 30% is discharged into the principal tributaries through which the wastes find their way to the boundary waters. The remaining portion of the industrial supply is discharged to municipal sewer systems.

Industries use a total of about 20 million (U. S.) gallons per day of water from municipal supplies. This water is used largely for drinking and sanitary purposes and, in general, ultimately reaches the boundary waters by way of the municipal sewers.

The Buffalo River, on which are located five major industries, receives large quantities of industrial wastes. Under conditions of low flows in the river as discussed in Chapter N-IV, the river becomes grossly polluted and septic action takes place. To alleviate this condition, the industries concerned have entered into an agreement with the Buffalo Sewer Authority to participate in a project to pump water from Lake Erie to the industries for cooling purposes. Since industries require from 120 to 150 million (U. S.) gallons per day, this volume of clean, cool, and alkaline water will have many benefits. It is anticipated that this amount of water will create sufficient flow in the Buffalo River to prevent concentration of wastes, as well as to provide the industries with a cleaner and cooler water.

The cost of the Lake Erie Cooling Water Project is estimated at $5,500,000. The general proposal has been approved and accepted by each of the five participating industries as well as the Buffalo Sewer Authority. However, problems relating to the financing of the project have not yet been fully solved.

Recreational Uses

The use of the boundary waters in the Lake Erie-Lake Ontario Section for bathing purposes is not extensive. The shore along Lake Erie on the Canadian side is widely used for bathing. Crystal Beach is the best known and offers both commercial and public bathing facilities. On the upstream end of Grand Island in the upper river, the State of New York maintains a public bathing beach in Beaver Island State Park. None of the municipalities maintain public beaches. Swimming along the waterfront of residential property is done on both the Canadian and United States shores of Lake Ontario. Pollution, especially along the United States side, has interfered with development of areas suitable for bathing.

The waters in the Buffalo area and in the lower Niagara River below Lewiston and Queenston are widely used for pleasure boating. Some 1,800 small power boats use the waters in the eastern end of Lake Erie and the upper Niagara River. About 160 of these boats are licensed on the Canadian side, while 800 are registered in Buffalo as being 16-foot length or over. Approximately 600 small power craft ply the lower river, 400 being registered in United States and 200 in Canada.

Fish and Wildlife

Commercial and sport fishing are practiced in the waters from the eastern part of Lake Erie to Lake Ontario, except in the sections of rapid flow in the Niagara River. The value of the Niagara River as a spawning area is considerable, there being large quantities of young fish in both the upper and lower river. The fact that Buffalo and other centers of population are adjacent to the area leads to wide recreational use of these waters for fishing. Poundage is secondary to the enjoyment of the sport.

Sport fishing in the eastern end of Lake Erie and the upper Niagara River is important. Species taken include blue and yellow pike, yellow perch, small and large mouth bass, whitefish, white bass, bullheads, northern pike, muskellunge, sturgeon, rock bass, and sunfish. Many man-days of fishing and many thousands of dollars are expended for this sport. Ice fishing for blue and yellow pike and yellow perch has been unusually productive in recent years. The lower Niagara River in the gorge is not suitable for angling, but the lower quiescent reaches are an important sport fishing ground for blue and yellow pike. Perch is predominant near the mouth of the river in Lake Ontario. Over a long period sport fishing in this area has increased.

Commercial fishing in these boundary waters is affected by regulations limiting the fishing methods that may be employed. On the United States side the netting of all fish except minnows is prohibited in the Niagara River, within five miles from the head of the river in Lake Erie and one-half mile from the Lake Erie shore elsewhere, and within one mile of the mouth in Lake Ontario and one-half mile from the Lake Ontario shore elsewhere. On the Canadian side, nets are prohibited in any river, creek, or within 1,000 yards of either side of the entrance thereto.

While Lake Erie is the most productive of the Great Lakes for commercial fishing, it is estimated that only about 3% of the bulk of the United States catch is taken in this area. Blue pike, ciscoes, and whitefish are the predominant species caught. Approximately 50,000 pounds of fish, worth about $7,000, are taken commercially by United States and Canadian interests from the eastern end of Lake Erie under investigation. About three-fourths of this catch is made in United States waters. Most of Lake Ontario is too deep for commercial fishing, but the shallow waters within a 15 mile radius of the Niagara River outlet are fairly productive. An estimate of about 130,000 pounds is caught annually in this area, with a value of about $20,000. Nearly all this amount is caught by United States licensed fishermen, and this comprises about half the total Lake Ontario catch on the United States side. As in Lake Erie, whitefish, ciscoes, and blue pike make up the bulk of the catch.

Wildfowl

The Niagara River flyway is considered one of the most important in New York State or the Province of Ontario. The area is therefore used for hunting of ducks and geese. Certain areas on both sides of the river, including Goat Island, are closed to hunting, but a considerable amount occurs along the eastern end of Lake Erie and in the open areas of the Niagara River.

No population census of migratory wildfowl has been made. Predominant types of ducks found in this area include the Black, the Mallard, and the Golden Eye. There is a substantial population of Black ducks on Goat Island, providing a tourist attraction. Especially during the spring migratory season the Niagara River flyway is used by the Canada goose.

Legislation

Administrative authority for remedial measures in pollution control is centered in the legislation enacted by various levels of governments in both countries. The several Federal, state, provincial, and municipal laws applicable to pollution control are discussed herewith.

Federal Legislation—United States

The United States Government now exercises pollution control mainly through four acts of legislation. The first of these is embodied in the provisions of Section 13 of the "Laws for the Protection and Preservation of the Navigable Waters of the United States" as included in the River and Harbor Act, approved March 3, 1899. This law prohibits the deposit of "any refuse matter of any kind or description whatever other than that flowing from streets and sewers and passing therefrom in a liquid state, into any navigable water of the United States or into any tributary of any water from which the same shall float or be washed into such navigable water."

The "Oil Pollution Act of 1924" deals specifically with deposition of oils from vessels into coastal or tidal navigable waters.

The Interstate Quarantine Regulations, Section 72.121, Part 72, Title 42, Code of Federal Regulations, prohibits the discharge of sewage, ballast or bilge water from vessels while operating on fresh water lakes and rivers within areas adjacent to domestic water intakes, as designated by the Surgeon General of the Public Health Service.

The most recent legislation enacted by the U. S. Government is Public Law 845, known as the "Water Pollution Control Act." This law, enacted June 30, 1948, is designed to "recognize, preserve and protect the primary responsibilities and rights of the States in controlling water pollution, to support and aid technical research to devise and perfect methods of treatment of industrial wastes which are not susceptible to known effective methods of treatment, and to provide Federal technical services to State and interstate agencies and to industries, and financial services to State and interstate agencies and to municipalities, in the formulation and execution of their stream pollution abatement programs." The authority and responsibilities relating to this Act are vested in the Public Health Service and the Federal Works Administration. The Public Health Service shall "in co-operation with other Federal agencies, with State water pollution control agencies, and interstate agencies, and with municipalities and industries involved, prepare or adopt comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof and improving the sanitary condition of surface and underground waters."

Federal Legislation — Canada

There is no Federal legislation in Canada which is concerned with pollution of water per se. There are, however, certain statutes which indirectly deal with the question of pollution and might, under appropriate circumstances, be successfully invoked.

The "Navigable Waters Protection Act," enacted in 1927, prohibits the throwing or depositing of "any sawdust, edgings, slabs, bark or rubbish, of any description whatsoever into any river, stream or other water, any part of which is navigable or which flows into any navigable water." It further prohibits the throwing or deposition of "any stone, gravel, earth, cinders, ashes or other material or rubbish liable to sink to the bottom in any navigable non-tidal waters of Canada where there are not at all times at least eight fathoms of water."

The "Fisheries Act," enacted in 1927, prohibits the discharge of ballast, coal ashes, stones, lime, chemical substances or drugs, dead or decaying fish, and other deleterious substances either on shore, between the high and low water levels, or into "any water frequented by fish, or that flows into such water, nor on ice over either such waters."

The "Migratory Birds Convention Act," enacted in 1927, prohibits the deposit or discharge of "oil, oil wastes, or deleterious substances . . . in any water frequented by migratory wildfowl, or that flows into such water, nor on ice over either of such waters."

Section 5(f) of the "National Health Act" of Canada, enacted in 1944, states that the Minister of National Health and Welfare shall enforce "any rules or regulations made by the International Joint Commission, promulgated pursuant to the treaty . . . so far as the same relate to public health."

The Criminal Code of Canada, Section 221, defines a common nuisance as "an unlawful act or omission to discharge a legal duty, which act or omission endangers lives, safety, health, proprety or comfort of the public, or by which the public are obstructed in the exercise or enjoyment of any right common to all His Majesty's subjects. R. S., c.146, s.221." Appropriate penalties are prescribed for anyone guilty of a common nuisance.

State of New York

Article V of the Public Health Law heretofore has governed the prevention of pollution of the waters of the state by requiring approval of plans and a permit from the State Commissioner of Health for the discharge of sewage or industrial wastes. One section of this law empowers the Commissioner of Health to issue orders requiring abatement of pollution when sewage or waste discharges are in quantities injurious to public health or when the conditions constitute a public nuisance. However, to be valid any such order issued by the Commissioner of Health must also be countersigned by both the Governor and Attorney General.

To improve water pollution control in the state, Chapter 666 of the Laws of 1949, constituting a new Article VI of the Public Health Law, was enacted to amend the Public Health Law, the Code of Criminal Procedure and the State Finance Law. This new law declares it to be the public policy of the state "to maintain reasonable standards of purity of the waters of the state consistent with public health and public enjoyment thereof, the propogation and protection of fish and wildlife, including birds, mammals and other terrestial and aquatic life, and the industrial development of the state, and to that end require the use of all known available and reasonable methods to prevent and control the pollution of the waters of the state of New York." Further, the new law declares its purpose to be to "Safeguard the waters of the state from pollution by: (a) preventing any new pollution, and (b) abating pollution existing when this law is adopted, under a program consistent with the declaration of policy above stated in the provisions of this article."

A Water Pollution Control Board is created by this new law, within the Department of Health and composed of the Commissioners of the State Departments of Health, Conservation, Agriculture and Markets, Commerce, and the Superintendent of Public Works. The State Commissioner of Health is chairman of this Board. An executive secretary, a duly qualified sanitary engineer, acts as administrative agent for the Board. This Board is vested with broad authority, power, and duties to require approval of plans and permits for all sewage or waste discharges; to adopt rules and regulations governing hearings, permits, and other procedures; and to classify all waters of the state and assign standards of quality to them, after public hearings to determine the best usage of such waters in the public interest. After a water has been classified and assigned standards of quality, the Board may issue orders requiring the discontinuance of any discharge of sewage or waste which contravenes the established standards. The Board is also authorized to conduct studies and research relating to pollution abatement and to encourage voluntary cooperation in pollution control.

As time will be required to make surveys needed for the classification of state waters, the act provides for the repeal or the continuance until April 1, 1959 of existing health laws relating to stream pollution. The existing conservation law will empower the Conservation Department to take action when pollution results in fish kills until the law is replaced on January 1, 1960, by Article VI of the Public Health Law.

New York State is by legislative action a member of the following three interstate compacts for the control of pollution, which have been authorized by the Congress of the United States and endorsed by the legislatures of the respective member states.

1. Interstate Sanitation Commission representing the states of New York, New Jersey, and Connecticut
2. Ohio River Valley Water Sanitation Compact between the states of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia, and West Virginia
3. New England Interstate Water Pollution Control Compact between the states of New Hampshire, Vermont, Maine, Rhode Island, Connecticut, and New York

In addition, legislative action by the states of New York, Pennsylvania, New Jersey and Delaware resulted in the formation of the Interstate Commission on the Delaware River (INCODEL) which functions through cooperative agreement of the member states.

As a signatory member of these three compacts and of the cooperative arrangement represented by INCODEL, New York State has agreed to carry out a pollution abatement program consistent with the minimum requirements of such compacts or agreements.

Province of Ontario

The Public Health Act of Ontario contains several sections dealing with pollution. Section 97 reads, "The Department (of Health) shall have the general supervision of all springs, wells, ponds, lakes, streams or rivers used as a source for a public water supply or for agricultural, domestic or industrial purposes with reference to their purity, together with the waters feeding the same, and shall examine the same from time to time when the necessity for such examination arises, and inquire what, if any, pollution exists and the causes thereof.

"The Department (of Health) may inquire into and hear and determine any complaint made by or on behalf of a riparian proprietor entitled to the use of water, that any industrial waste or any other polluting material of any kind whatsoever which either by itself or in connection with other matter may corrupt or impair the quality of the water or may render such water unfit for accustomed or ordinary use has been placed in, or discharged into such water, or placed or deposited upon the ice thereof, or placed or suffered to remain upon the bank or shore thereof."

Section 98 of this same act prohibits the discharge of pollution and reads as follows: "No garbage, excreta, manure, vegetable or animal matter or filth shall be discharged into or be deposited in any of the lakes, rivers, streams or other waters in Ontario or on the shores or banks thereof, and no industrial or other wastes, dangerous or liable to become dangerous to health or to become a nuisance, or to impair the safety, palatability or potability of the water supply of any municipality or riparian owner, shall be discharged into or be deposited in any of the lakes, rivers, streams, or other waters of Ontario, or on the shores or banks thereof.

"The owners and officers of boats and other vessels plying upon any such lake, river, stream or other water shall so dispose of the garbage, excreta, manure, vegetable or animal matter or filth upon such boats or vessels as not to create a nuisance or enter or pollute such lake, river, stream or other water."

Section 100 of "The Public Health Act" prohibits pollution of public water supplies. "No sewage, drainage, domestic, commercial or factory refuse, excremental or other polluting matter of any kind whatsoever which either by itself or in connection with other matter corrupts, pollutes or impairs or may corrupt, pollute or impair the quality of the water of any source of public water supply for domestic use in any municipality, or which renders or may render such water injurious to health shall be placed in, deposited on, or discharged into the waters, or placed or deposited upon the ice of any such source of water supply, or be placed, deposited or discharged, or suffered to remain in, on or upon the bank or shore of any such source of water supply, or in, or upon any lands adjacent to any such source, nor shall any person bathe or swim in the water of any such source of water supply."

The approval of the Department of Health is required before work is undertaken on any public waterworks or sewerage system. Similarly, the Department has authority to require that any waterworks or sewerage system be constructed, extended, enlarged or altered.

An amendment to "The Rivers and Lakes Improvement Act" passed in 1949 reads as follows: "Section 30 of The Lakes and Rivers Improvement Act is repealed and the following substituted therefor:

"In this section 'mill' means a plant or works in which logs or woodbolts are processed and includes a saw mill, a pulp mill, and a pulp and paper mill.

"Where in an action or proceeding a person claims, and but for this section would be entitled to, an injunction against the owner or occupier of a mill for an injury or damage, direct or consequential, sustained by such person, or for any interference directly or indirectly with any rights of such person as riparian proprietor or otherwise, by reason or in consequence of the throwing, depositing, or discharging, or permitting the throwing, depositing or discharging of any refuse, sawdust, chemical substance or matter from the mill or from it and other mills into any lake or river, or by reason or in consequence of any odour arising from any such refuse, sawdust, chemical substance or matter so thrown, deposited or discharged or so permitted to be thrown, deposited or discharged, the court or judge may:—

(a) refuse to grant an injunction if it is proved that having regard to all the circumstances and taking into consideration the importance of the operation of the mill to the locality in which it operates and the benefit and advantage, direct and consequential, which the operation of the mill confers on that locality and on the inhabitants of the locality, and weighing the same against the private injury, damage or interference complained of, it is on the whole proper and expedient not to grant the injunction; or

(b) grant an injunction to take effect after such lapse of time or upon such terms and conditions or subject to such limitations or restrictions as may be deemed proper; or

(c) in lieu of granting an injunction, direct that the owner or occupant of the mill take such measures or perform such acts to prevent, avoid, lessen or diminish the injury, damage or interference complained of as may be deemed proper.

"Nothing in subsection 2 shall affect any right of the person claiming the injunction to damages against the owner or occupier of the mill for any such injury damage or interference.

"Where damage from the same cause continues the person entitled to the damages may apply from time to time in the same action or proceeding for the assessment of subsequent damages or for any other relief to which by subsequent events he may from time to time become entitled.

"This section shall apply whether the injury, damage or interference is or is not a continuing one, and whether the person claiming the injunction in the action or proceeding is a plaintiff or is a defendant proceeding by way of counterclaim.

"Section 30 of 'The Lakes and Rivers Improvement Act,' as re-enacted by subsection 1 of this section, shall apply to every action or proceeding in which an injunction is claimed in respect of any of the matters mentioned in such section, including every action or proceeding in which an injunction has been granted and in which any appeal is pending."

Municipal Regulations

Municipalities are authorized to enact regulations or by-laws dealing with such local matters as control of pollution, restrictions on the use of sewers, setting rates for sewer service rates, and financing.

Chapter N-VI

WATER-BORNE DISEASES

> "Public health is purchasable. Within natural limitations any community can determine its own death rate."
>
> —Herman M. Biggs.

The incidence of water-borne diseases has been utilized for many years to evaluate the effects of sewage pollution. Statistical data on these diseases are available for long periods. For purposes of this investigation these records have been confined to typhoid fever and other enteric diseases. These diseases have been associated conspicuously with public water supplies, either in the form of actual outbreaks or as potential menaces.

Epidemiological Studies

The findings of the 1913 survey, as recorded in the Progress Report of the International Joint Commission, dated January 16, 1914, have been reviewed. At that time two special reports were presented as appendices: "Sanitary Conditions in Cities and Towns Situated on the United States Side of the Boundary Waters with Special Reference to Typhoid Fever," and "Typhoid Fever Statistics and Some Sanitary Facts Affecting its Undue Prevalence in Ontario." Typhoid fever death rates were given for various municipalities along the boundary waters. The excessive prevalence of this disease on the United States side, especially in the winter and spring months, was attributed in greatest measure to the sewage pollution of the interstate and international waters used as sources of public water supply. It was also stated that in Ontario the typhoid rates were excessive in most parts of the province, and they were highest of all in those muncipalities situated on the international waters. Their studies led the investigating authorities to conclude that high typhoid rates in cities and towns were closely related to sewage pollution of water supplies.

Comparable statistics for 1948, presented in table N-10, show that typhoid fever has been virtually eliminated. No typhoid fever outbreak attributable to a public water supply has occurred along the Niagara Frontier during the past 15 years.

There have been no deaths from typhoid fever since 1940 in the places noted in table N-10 except for two in Buffalo in 1944, and two in Buffalo and one in Niagara County in 1942. Typhoid fever deaths have been allocated to place of origin of disease since 1932.

The 1913 report refers to the prevalence of "winter cholera", a local name for unclassified diarrheal diseases prevalent in the area. Cases of water-borne enteric diseases reported to health officials have been restricted to typhoid fever, bacillary and amoebic dysentery, and diarrhea of the newborn. Hence, unclassified diarrheal diseases cannot be subjected to statistical study, ex-

TABLE N-10—TYPHOID FEVER MORTALITY

Total Deaths and Death Rates Per 100,000 Population

Municipality	1913		1920		1930		1940		1948	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
State of New York	1,018	10.6	371	3.5	148	1.2	26	0.2	6	<0.05
Lackawanna	0	0	1	5.5	1	4.2	0	0	0	0
Buffalo	68	15.4	26	5.1	11	1.9	0	0	0	0
Tonawanda	3	34.0	2	19.6	0	0	0	0	0	0
North Tonawanda	2	15.5	3	19.2	0	0	0	0	0	0
Lockport	13	70.6	1	4.7	2	8.6	1	4.1	0	0
Niagara Falls	10	26.4	4	7.8	0	0	0	0	0	0
Lewiston	0	0	0	0	0	0	0	0	0	0
Youngstown	0	0	0	0	0	0	0	0	0	0
Province of Ontario	446	16.7	203	7.0	76	2.3	26	0.7	6	0.1
Fort Erie	....	....	0	0	0	0	0	0	0	0
Chippawa	....	....	0	0	0	0	0	0	0	0
Niagara Falls	8	66.6	3	20.3	1	5.4	0	0	0	0
Welland	8	123.6	2	20.6	1	9.9	0	0	0	0
Niagara	....	....	0	0	0	0	0	0	0	0

cept when the number of such cases is sufficient to disclose the occurrence of outbreaks.

An outbreak of water-borne gastroenteritis occurred in Niagara Falls, New York, in 1933, involving approximately 10,000 cases. No cases of typhoid fever or bacillary dysentery were reported. This outbreak was due to a lapse in effective chlorination of the public water supply during a period when the chlorine dose was not adjusted sufficiently and quickly enough to compensate for a very sudden, tenfold increase in chlorine demand of the raw water. Investigation disclosed that an ice jam in the Niagara River and in Buffalo Harbor had led to retention of polluted water. A sudden disintegration of the ice jam following a rapid thaw accompanied by heavy rainfall, led to the flushing of this heavily polluted water into the upper Niagara River. This episode again focuses attention upon the basic importance of meteorological conditions and the unusual stream flow characteristics in the Niagara River in determining the distribution of polluted water, as discussed elsewhere in this report.

The previous report contained no data on diseases attributable to swimming in the Niagara River. Since that time no statistics have been recorded on this subject.

Effect of Water Purification

The fact that water-borne typhoid fever has virtually disappeared must not be construed to mean that the pollution of sources of water supply has diminished to the same extent. Several factors have contributed to this reduction. The installation and effective operation of modern water treatment plants is of major importance. The diminishing number of typhoid carriers discharging pathogenic micro-organisms into sewage reaching these waters is also of prime importance. The treatment of sewage from Buffalo and other municipalities has reduced the bacterial pollution received by the river despite a steadily increasing contributory population. All of these factors have made it possible to avoid outbreaks of water-borne diseases even under adverse circumstances. Pollution by industrial wastes has greatly complicated water purification. Chlorination for disinfecting purposes is rendered more difficult because of the fluctuating degree of pollution. Complex taste and odor problems have been created by industrial waste pollution. The magnitude of these problems has focused attention on the superior quality of water in the westerly portion of the upper river and is prompting extension of water supply intakes on the United States side into these waters.

Epidemiological data as to water-borne typhoid fever was given major consideration in the 1913 investigation because the prevalence of this disease was the best criterion for determining the public health effect of the pollution of the waters. Under present conditions careful consideration must be given to the growing problem of producing potable water of attractive physical character in an economical manner. Yardsticks, other than water-borne diseases, must also be utilized in appraising the significance of pollution of the Niagara River.

Chapter N-VII

SOURCE AND CHARACTER OF POLLUTION

> "The shape of things tomorrow is dependent on the shape of things today."
> —The Harvard Fund Council.

Pollution in these boundary waters originates principally from domestic and industrial wastes from sources located along the shores. These wastes are of primary importance since their effects are imposed directly on the boundary waters. Sources of pollution on tributary streams were also studied to ascertain if the effects of those wastes were transmitted to the boundary waters.

Data on domestic wastes were secured from complete sampling and gaging studies conducted at two of the sewage treatment plants, and from local, state and provincial authorities.

Thirty-four industrial plants were studied during the investigation, thirty being in the United States and four in Canada. Complete sampling and gaging studies were made at eight of these thirty-four industries by the field technical staff. Industry itself conducted gaging and sampling studies at many of those industries where little information was available. Data on the wastes were reviewed and agreed to in all cases by the industry concerned.

Vessels engaged in freight and passenger traffic, particularly in the Lake Erie and upper Niagara River area, contribute pollution by their sewage and refuse. Pleasure craft also ply these boundary waters, but it is not believed they contribute a serious pollution load.

Domestic Wastes

All of the larger municipalities are sewered, and in 16 out of a total of 20 municipalities, the sewage is subjected to some degree of treatment.

TABLE N-11—PRINCIPAL SOURCES OF DOMESTIC SEWAGE

Municipality	Receiving Stream or Lake	Population		Degree of Treatment
		Total (Est. 1948)	Served by Sewers	
United States:				
Wanakah Sewer District, Town of Hamburg.	Lake Erie	920	920	Primary
Mt. Vernon Sewer District, town of Hamburg.	Lake Erie	2,500	2,500	Primary
Woodlawn Sewer District, Town of Hamburg.	Lake Erie via Rush Creek	2,000	2,000	Secondary
Blasdell Village	Lake Erie via Rush Creek	3,000	3,000	Secondary
Lackawanna City	Lake Erie via Smokes Creek	30,000	30,000	Secondary
Buffalo City	Upper Niagara River	617,937	600,000	Primary
Grand Island Sewer District No. 1	Upper Niagara River, East Channel	650	650	Primary
Tonawanda City	Upper Niagara River, East Channel	15,000	15,000	Primary
North Tonawanda City	Upper Niagara River, East Channel	27,000	27,000	None
Town of Tonawanda, Sewer District No. 2.	Upper Niagara River, East Channel via Two Mile Creek.	35,000	35,000	Primary
Town of Tonawanda, Sewer District No. 3.	Upper Niagara River, East Channel via Ellicott Creek.	1,000	1,000	Secondary
Niagara Falls City	Lower Niagara River	92,000	105,450	Primary
Youngstown Village	Lake Ontario	800	1,500	Primary
Canada:				
Crystal Beach Village	Lake Erie	1,300	1,300 (8,000 Summer)	Secondary
Fort Erie Town	Upper Niagara River	7,500	7,500	Septic Tanks
Niagara Falls City	Lower Niagara River	22,000	22,000	None
Chippawa Village	Lower Niagara River via Welland River and Queenston Canal.	1,600	1,600	Septic Tanks
Welland City	Lower Niagara River via Welland River and Queenston Canal.	16,000	16,000	None
Stamford Township	Lower Niagara River via Welland River and Queenston Canal.	13,500	8,000	Septic Tanks (Part)
Niagara Town	Lake Ontario	1,900	1,200 (3,000 Summer)	None

There are also several small communities with waterworks systems, where sewers ultimately will be built. These constitute a potential pollution problem unless treatment works are also constructed. Information on the main sources of domestic sewage for this section of the boundary waters is recorded in table N-11. It should be noted that the population figures do not include any equivalent for industrial wastes entering the public sewer systems.

The municipalities served by sewage treatment are located along the entire stretch of boundary waters. Twelve of these treatment works are located in the United States and four in Canada. The data presented in table N-11 are summarized in table N-12 to show the population contributory to the various areas of the boundary waters.

TABLE N-12—SUMMARY OF SEWAGE COLLECTION AND TREATMENT BY AREAS

Area	Total Population (Est. 1948-49)	Population Served		
		By Sewers Only	By Sewers and Treatment	Total
Lake Erie.........	39,700	....	39,700	39,700
Upper Niagara River...........	706,400	27,000	659,300	686,300
Lower Niagara River...........	163,600	38,000	115,100	153,100
Lake Ontario.....	3,400	1,200	1,500	2,700
Total.....	913,100	66,200	815,600	881,800

Except for approximately 30,000 persons, all of the total estimated population of nearly 915,000 situated along the boundary waters are served by sewer systems. Treatment facilities are provided for about 92% of the population served by sewers. The plant of the Buffalo Sewer Authority alone serves 618,000 persons or 70% of this total. Most of these sewer systems are of the combined type with storm water and sewage carried in the same sewer. Table N-12 shows a high percentage of the population being served by sewage treatment. About 5% of this population is served by plants employing secondary or biological treatment.

The total estimated volume of municipal sewage discharged to the waters of these areas is tabulated in table N-13. These totals include wastes contributed by industries located within the municipalities and connected to the public sewer system.

Sewage Treatment Plants

The largest sewage treatment works in this area, operated by the Buffalo Sewer Authority to serve the City of Buffalo, provides primary treatment, chlorination of the effluent, separate sludge digestion, and incineration of the sludge. The City of Lackawanna plant employs secondary treatment, the effluent being discharged to Smokes Creek, a tributary of Lake Erie. The Town of Tonawanda operates two sewage treatment works, one providing biological treatment. The effluents from both plants discharge to tributaries of the upper Niagara River. The City of Tonawanda plant, providing primary treatment, discharges directly to the upper Niagara River. The treatment works of the City of Niagara Falls, New York, comprises a fine screening plant, with chlorination of the effluent during the summer months. It discharges to the lower Niagara River.

TABLE N-13—VOLUME OF MUNICIPAL SEWAGE
(Average Annual)

Area	Volume—Million Gallons per Day			
	United States (U. S. Gallons)	Canada (Imp. Gallons)	Total—Both Sides	
			U. S. Gallons	Imp. Gallons
Lake Erie.........	3.8	0.4	4.3	3.6
Upper Niagara River............	127	0.8	128	107
Lower Niagara River............	82	10.7	95	79
Lake Ontario......	0.3	0.5	0.9	0.8
Total......	213	12.4	228	190

The Village of Crystal Beach on the Canadian side employs secondary treatment by activated sludge, the plant effluent being discharged to Lake Erie.

Details of the various plants are as follows:

Wanakah Plant, New York

Operated by: Board of Sewer Commisisoners, Wanakah Sewer District
Communities Served: Wanakah hamlet
Treatment: Sedimentation (Imhoff tanks), sludge drying beds, postchlorination
Design Flow: 0.12 M.G.D. (U.S.)
Present Flow: 0.115 M.G.D. (U.S.)
Design Population: 400 persons winter; 1,600 persons summer
Population Served: 920 persons
Receiving Stream: Lake Erie

Mt. Vernon Plant, New York

Operated by: Board of Sewer Commissioners, Mt. Vernon Sewer District
Communities Served: Hamlets of Mt. Vernon, Locksley Park and Cloverbank
Treatment: Sedimentation (Imhoff tank), postchlorination with contact tank, and covered sludge drying beds

Design Flow: 0.625 M.G.D. (U.S.)
Present Flow: 0.65 M.G.D. (U.S.)
Design Population: 7,500 persons
Population Served: 2,500 persons
Receiving Stream: Lake Erie

Woodlawn Plant, New York

Operated by: Board of Sewer Commissioners, Woodlawn Sewer District
Communities Served: Woodlawn hamlet
Treatment: Sedimentation (Imhoff tank), trickling filter, final sedimentation, postchlorination, covered sludge drying beds
Design Flow: 0.24 M.G.D. (U.S.)
Present Flow: 0.10 M.G.D. (U.S.) Dry-weather flow
Design Population: 2,400 persons
Population Served: 2,000 persons
Receiving Stream: Rush Creek, tributary to Lake Erie

Blasdell Plant, New York

Operated by: Village of Blasdell
Communities Served: Village of Blasdell
Treatment: Bar screen, sedimentation (Imhoff tank), trickling filter, and sludge drying bed
Design Flow: 0.44 M.G.D. (U.S.)
Present Flow: 0.25 M.G.D. (U.S.)
Design Population: 4,000 persons
Population Served: 3,000 persons
Receiving Stream: Rush Creek, tributary to Lake Erie

Lackawanna Plant, New York

Operated by: City of Lackawanna
Communities Served: City of Lackawanna
Treatment: Sedimentation (Imhoff tank), trickling filter, postchlorination, final sedimentation and covered sludge drying beds. One of the three storm-overflow pump stations is equipped with grit chamber, bar screen, comminutor, and chlorination. All other excess storm water is chlorinated and by-passed to Smokes Creek.
Design Flow: 2.5 M.G.D. (U.S.)
Present Flow: 2.7 M.G.D. (U.S.) Dry-weather flow
Design Population: 25,000 persons
Population Served: 30,000 persons
Receiving Stream: Smokes Creek, tributary to Lake Erie

Buffalo Plant, New York

Operated by: Buffalo Sewer Authority
Communities Served: City of Buffalo
Treatment: Chlorination, sedimentation, sludge digestion, vacuum filtration, incineration
Design Flow: 150 M.G.D. (U.S.)
Present Flow: 113 M.G.D. (U.S.)
Design Population: 750,000 persons
Population Served: 600,000 persons (Exclusive of industrial waste)
Receiving Stream: Upper Niagara River

Grand Island Plant, New York

Operated by: Town of Grand Island
Communities Served: Sewer District No. 1
Treatment: Comminutor, prechlorination, sedimentation, vacuum filtration
Design Flow: 0.14 M.G.D. (U.S.)
Present Flow: 0.06 M.G.D. (U.S.)
Design Population: 1,200 persons
Population Served: 650 persons
Receiving Stream: Upper Niagara River, East Channel

City of Tonawanda Plant, New York

Operated by: City of Tonawanda
Communities Served: City of Tonawanda
Treatment: Grit removal, sedimentation, chlorination, separate sludge digestion and vacuum filtration
Design Flow: 3.50 M.G.D. (U.S.)
Present Flow: 3.5 M.G.D. (U.S.) Dry-weather flow
Design Population: 22,000 persons
Population Served: 15,000 persons
Receiving Stream: Upper Niagara River, East Channel

Town of Tonawanda – Sewer District No. 2 Plant, New York

Operated by: Town of Tonawanda
Communities Served: Village of Kenmore
Treatment: Sedimentation, separate sludge digestion, sludge drying beds, pre- and postchlorination
Design Flow: 3.5 M.G.D. (U.S.)
Present Flow: 3.5 M.G.D. (U.S.)
Design Population: 35,000 persons
Population Served: 35,000 persons
Receiving Stream: Two Mile Creek, tributary to upper Niagara River, East Channel

Town of Tonawanda – Sewer District No. 3 Plant, New York

Operated by: Town of Tonawanda
Communities Served: Town of Tonawanda
Treatment: Sedimentation (Imhoff tank), trickling filters, covered sludge drying beds. No chlorination.
Design Flow: 0.50 M.G.D. (U.S.)
Present Flow: 0.75 M.G.D. (U.S.)
Design Population: 5,000 persons
Population Served: 1,000 persons
Receiving Stream: Ellicott Creek, tributary to upper Niagara River, East Channel.

Niagara Falls Plant, New York

Operated by: City of Niagara Falls
Communities Served: City of Niagara Falls and surrounding area in Towns of Wheatfield and Niagara
Treatment: Grit chambers, fine screens, chlorination of effluent during summer, sludge dewatering and incineration
Design Flow: 40 M.G.D. (U.S.) with filter medium; 90 M.G.D. (U.S.) without
Present Flow: 75 M.G.D. (U.S.) average
Population Served: 105,450 persons (Exclusive of industrial wastes)
Receiving Stream: Lower Niagara River

Youngstown Plant, New York

Operated by: Village of Youngstown
Communities Served: Village of Youngstown
Treatment: Bar screen, sedimentation (Imhoff tank), sludge drying beds, chlorination
Design Flow: 0.548 M.G.D. (U.S.)
Present Flow: Estimated 0.25 M.G.D. (U.S.)
Design Population: 2,500 persons
Population Served: 1,500 persons
Receiving Stream: Lake Ontario

Crystal Beach Plant, Ontario

Operated by: Crystal Beach Village
Communities Served: Crystal Beach Village
Treatment: Activated sludge, postchlorination, sludge burial
Design Flow: 0.30 M.G.D. (Imp.)
Present Flow: 0.15 M.G.D. (Imp.) in winter; 0.6 M.G.D. (Imp.) in summer
Design Population: 3,000 persons
Population Served: 1,300 (8,000 in summer)
Receiving Stream: Lake Erie

Fort Erie Plant, Ontario

Operated by: Town of Fort Erie
Communities Served: Town of Fort Erie
Treatment: Septic Tank
Design Flow: 0.10 M.G.D. (Imp.)
Present Flow: 1.2 M.G.D. (Imp.)
Design Population: 2,000 persons
Population Served: 7,500 persons
Receiving Stream: Upper Niagara River

Chippawa Plant, Ontario

Operated by: Village of Chippawa
Communities Served: Village of Chippawa
Treatment: Two Septic Tanks
Design Flow: No data available
Present Flow: 0.4 M.G.D. (Imp.)
Population Served: 1,600 persons
Receiving Stream: Welland River, tributary to lower Niagara River via H.E.P.C. power canal

Stamford Plant, Ontario

Operated by: Township of Stamford
Communities Served: Township of Stamford
Treatment: Three Septic Tanks
Design Flow: No data available
Present Flow: 1.1 M.G.D. (Imp.)
Population Served: 8,000 persons
Receiving Stream: H.E.P.C. power canal, tributary to lower Niagara River

The effectiveness of treatment by several of these plants is not disclosed by the facilities provided. On the United States side, both the Lackawanna and the Blasdell plants are considerably overloaded, and as they discharge into small creeks local authorities have instigated action to ameliorate the pollution problems. Thus, efforts have been made to enlarge the Lackawanna plant and plans have been prepared for a new plant at Blasdell. On the Canadian side, the Crystal Beach treatment works are considerably overloaded for secondary treatment during the summer resort period. Also, the septic tank treatment at Fort Erie, Chippawa, and Stamford Township is inadequate.

Of even greater significance than the overloaded plants are those municipalities discharging untreated sewage into the boundary waters. The cities of North Tonawanda, New York, and Niagara Falls, Ontario, both discharging directly to the Niagara River, are the principal offenders. Also of importance is the City of Welland which discharges its untreated sewage to the lower river by way of the Hydro Electric Power Commission's power canal, and Stamford Township, discharging about half its raw sewage to the lower Niagara River.

Abatement of pollution from domestic sewage will require collection and treatment for the entire area.

Combined Sewer Overflows

With combined sewer systems, large volumes of sanitary sewage and process wastes reach the boundary waters during periods of excessive storm run-off. In these combined systems, the sewers are designed to carry the dry-weather flow, together with some multiple of this flow as storm water. Usually this multiple does not exceed two or three. Consequently, during periods of storm run-off exceeding this amount, the excess mixture of storm and sanitary flow, instead of going to the sewage treatment plant, discharges directly to the boundary waters or their tributaries through combined sewer overflows.

Most of the sewers in this area are of combined type, hence storm water overflows are numerous. The major ones are located along the Buffalo River and the Niagara River in the cities of Buffalo, Tonawanda, and Niagara Falls, New York. In Buffalo there are 34 overflows discharging to the Buffalo River, 12 to the harbor area, and 4 to the upper Niagara River. The City of Tonawanda has three overflows that discharge to the upper Niagara River and Ellicott Creek. Niagara Falls, New York, maintains eight overflows, all discharging to the lower Niagara River. Of the Canadian communities, none has combined storm water overflows.

The above combined sewer overflows do not receive any treatment, and consequently, full benefit from existing interceptors and treatment facilities is not realized. Intermittent pollution occurs under those conditions. The City of Lackawanna, however, chlorinates excess storm water before it overflows to Smokes Creek, a tributary of Lake Erie.

Refuse Disposal

An added factor in the pollution problem of these boundary waters is the careless and thoughtless disposal of garbage and other refuse. Such wastes add pollution, create an unsightly appearance, and present hazards to small watercraft. The wastes originate from ships, shore residences and from wilful dumping by careless persons.

While much refuse was formerly dumped by the municipalities into the Niagara River, there is little evidence, with the exception of Niagara Falls, New York, that pollution from such sources has taken place recently. Garbage is usually disposed of by incineration or used as fertilizer or hog feed. Many of the small communities have contracts with private concerns who bury the garbage. Ashes and rubbish are either incinerated or used as land fill. Niagara Falls, New York normally incinerates refuse, with the ashes being used as fill. However, in 1949 when the breakdown of an incinerator unit made emergency disposal necessary, garbage was dumped into the river for several weeks until discovered by a representative of the New York State Department of Health. Conferences with the city officials resulted in its immediate discontinuance.

The practice of dumping refuse in locations where it can drain into or directly enter these waters is highly objectionable, and all means should be taken to prevent it.

Industrial Wastes

Industrial wastes are the chief sources of chemical pollution, as distinguished from bacterial pollution in sewage, and they are much less significant from the standpoint of disease. The chief objection to many of these wastes is that they contain taste and odor producing compounds, chlorine-consuming compounds, and toxic substances. Other polluting effects result from the discharge of oils, solids, acids, oxygen-consuming wastes, and other materials which impart an unsightly appearance, and otherwise injuriously affect the usage of the waters.

Pollution by industrial wastes occurs mainly on the United States side at the east end of Lake Erie, the Buffalo River, and along the east side of the upper Niagara River. There is no industrial pollution directly into the lower Niagara River except through the Niagara Falls, New York, diversion sewer system and through the power canal of the Ontario Hydro Electric Power Commission.

The 34 major industries which were studied are listed in table N-14 by types of production.

TABLE N-14—NUMBER AND TYPES OF INDUSTRIES STUDIED

Type of Industry	Number of Plants		
	United States	Canada	Total
Automotive	1	0	1
Chemical	9	2	11
Coke and By-Products	2	0	2
Gas Manufacturing	2	0	2
Oil Refinery	2	0	2
Paper and Fibre Products	5	0	5
Rubber	1	0	1
*Steel	4	0	4
Electrothermal	2	2	4
Synthetic Fibre	1	0	1
Miscellaneous	1	0	1
Total	30	4	34

*One of the steel plants operates a coke plant not included above.

Information on industrial wastes produced daily in the Lake Erie-Lake Ontario Section is contained in table N-15. The flows shown in the table include cooling and condenser waters as well as process wastes. Also included in this table are the industrial waste discharges to the City of Niagara Falls, New York, sewage treatment works. This is primarily a screening plant and since it was not designed to remove industrial waste pollutants, such wastes tend to pass through without modification.

Where industrial wastes are discharged into the tributary streams, the total amounts of the polluting constituents may not reach the boundary waters since natural purification tends to reduce or alter such substances as phenols, cyanides, and ammonium and sulfur compounds.

Origin of Wastes

The significant waste constituents shown in table N-15 result from a variety of industrial processes. Each plant may produce one or more of these substances. They are discharged at both uniform

TABLE N-15—SUMMARY OF INDUSTRIAL WASTES DISCHARGED DAILY

Area	Total Flow		Phenol (Pounds)	Cyanides as CN- (Pounds)	Ammonium Compounds as NH_3 (Pounds)	Oil and Ether-Extractable Materials		Suspended Solids (Pounds)
	Million Gallons (U. S.)	Million Gallons (Imp.)				U. S. Gallons	Imp. Gallons	
UNITED STATES SIDE								
Lake Erie	155	129	120	0	5,530	990	825	180,900
Niagara River	305	254	6,250	1,720	655	900	750	567,200
Lake Ontario	0	0	0	0	0	0	0	0
Total	460	383	6,370	1,720	6,185	1,890	1,575	748,100
CANADIAN SIDE								
Lake Erie	0	0	0	0	0	0	0	0
Niagara River	36	30	0	35	4,380	0	0	9,030
Lake Ontario	0	0	0	0	0	0	0	0
Total	36	30	0	35	4,380	0	0	9,030
COMBINED—UNITED STATES AND CANADA								
Lake Erie	155	129	120	0	5,530	990	825	180,900
Niagara River	341	284	6,250	1,755	5,035	900	750	576,230
Lake Ontario	0	0	0	0	0	0	0	0
Total	496	413	6,370	1,755	10,565	1,890	1,575	757,130

rates and in batches of varying concentrations, the latter constituting a slug or a spill.

Phenolic Compounds

Phenol and phenolic equivalents originate from by-product coke and gas plant operations, crude oil refining, blast furnaces, and from plants in which phenol is used as a raw material.

Phenol compounds were found only on the United States side, in the wastes from

Semet-Solvay Division, Allied Chemical & Dye Corporation
Durez Plastics & Chemicals, Inc.
Donner-Hanna Coke Corporation
National Aniline Division, Allied Chemical & Dye Corporation
Spaulding Fibre Company, Inc.
Republic Steel Corporation
Bethlehem Steel Company
Socony-Vacuum Oil Company, Inc.
Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation
Carborundum Company
Hooker Electrochemical Company

Cyanides

Cyanides originate chiefly from by-product coke ovens, electroplating processes, tar processing plants, blast furnaces, oil refineries, and some chemical manufacturing plants. Cyanides were found on the United States side in the wastes from

Donner-Hanna Coke Corporation
E. I. duPont de Nemours & Co., Electrochemicals Department
National Aniline Division, Allied Chemical & Dye Corporation
Semet-Solvay Division, Allied Chemical & Dye Corporation
Republic Steel Corporation
Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation
Socony-Vacuum Oil Company, Inc.

and on the Canadian side from

North American Cyanamid Limited, Welland Works

Ammonium Compounds

Ammonium compounds are found in the wastes from by-product coke ovens, chemical plants, gas plants, and tar processing plants. They were present, on the United States side, in the wastes from

Bethlehem Steel Corporation
Durez Plastics & Chemicals, Inc.
Semet-Solvay Division, Allied Chemical & Dye Corporation
Donner-Hanna Coke Corporation

and on the Canadian side from

North American Cyanamid Limited, Welland Works

Oils and Other Ether-Extractable Materials

Oils and other ether-extractable materials were found on the United States side only, in the wastes from

- Bethlehem Steel Company
- Chevrolet-Tonawanda, Division of General Motors Corporation
- Socony-Vacuum Oil Company, Inc.
- Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation
- Semet-Solvay Division, Allied Chemical & Dye Corporation
- Frontier Oil Refining Corporation
- Donner-Hanna Coke Corporation

Suspended Solids

Suspended solids were found, on the United States side, to be contributed chiefly from

- Bethlehem Steel Company
- International Paper Company, Niagara Falls Plant
- Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation
- E. I. duPont de Nemours & Co., Inc., Electrochemicals Department
- Electro Metallurgical Division, Union Carbide & Carbon Corporation
- National Aniline Division, Allied Chemical & Dye Corporation
- International Paper Company, Tonawanda Plant
- Republic Steel Corporation
- Carborundum Company
- Kimberly-Clark Corporation
- E. I. duPont de Nemours & Co., Inc., Rayon Division
- Semet-Solvay Division, Allied Chemical & Dye Corporation
- Tonawanda Boxboards Division, Robert Gair Company, Inc.
- Mathieson Chemical Corporation
- Spaulding Fibre Company, Inc.
- Donner-Hanna Coke Corporation
- Durez Plastics & Chemicals, Inc.
- Hooker Electrochemical Company
- Oldbury Electro-Chemical Company
- Chevrolet-Tonawanda, Division of General Motors Corporation

and on the Canadian side from

- North American Cyanamid Limited, Welland Works
- North American Cyanamid Limited, Niagara Falls Plant
- Norton Company
- Canadian Carborundum Company

Biochemical Oxygen Demand

Biochemical oxygen demand is due to organic materials. Substantial amounts were found, on the United States side, in the wastes from

- National Aniline Division, Allied Chemical & Dye Corporation
- International Paper Company, Niagara Falls Plant
- International Paper Company, Tonawanda Plant
- Donner-Hanna Coke Corporation
- Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation
- E. I. duPont de Nemours & Co., Inc., Rayon Division
- Durez Plastics & Chemicals, Inc.
- Semet-Solvay Division, Allied Chemical & Dye Corporation
- Hooker Electrochemical Company
- E. I. duPont de Nemours & Co., Inc., Electrochemicals Department
- Bethlehem Steel Company

The biochemical oxygen demand (B.O.D.) test of a waste is a measurement of the strength or concentration of its oxidizable organic matter. The "Population Equivalent" value provides a basis on which industrial wastes may be compared with domestic sewage insofar as oxygen-consuming qualities are concerned. The coefficient of 0.17 pound of 5-day, 20° C., B.O.D. per capita per day is used for converting the B.O.D. value to a population equivalent figure. The B.O.D. of the industrial wastes and their corresponding population equivalents are listed in table N-16. These figures do not necessarily imply an equivalent bacterial pollution load.

TABLE N-16—POPULATION EQUIVALENT OF INDUSTRIAL WASTE DISCHARGES

Area	B. O. D.—Pounds Daily			Population Equivalent—Persons		
	United States	Canada	Total	United States	Canada	Total
Lake Erie	*	0	....	*	0	....
Niagara River	96,000	*	96,000+	565,100	*	565,100+
Lake Ontario	0	0	0	0	0	0
Total	96,000+	0	96,000+	565,100+	0	565,100+

*Amount undetermined.

Miscellaneous

Miscellaneous polluting substances, as indicated, were found on the United States side in wastes from

General Chemical Division, Allied Chemical & Dye Corporation	Acid
Bethlehem Steel Company	Acid, iron, sanitary sewage
National Aniline Division, Allied Chemical & Dye Corporation	Acid, iron
Niacet Chemicals Division, United States Vanadium Corporation, Unit of Union Carbide & Carbon Corp.	Acid, zinc
Republic Steel Corporation	Iron
Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation	Iron
E. I. duPont de Nemours & Co., Inc. Rayon Division	Acid, zinc

Wastes From Dredging

The deposition of solids in the Buffalo River, the Buffalo River entrance channel, Buffalo Outer Harbor, and the upper Niagara River is caused by soil erosion on the watershed and from the large amounts of domestic and industrial wastes discharged into these waters. The U. S. Army, Corps of Engineers, has an annual program of maintenance dredging for navigation purposes. The annual expenditure for this work now amounts to about $200,000, of which $150,000 is spent in maintaining the Buffalo River. Deepening a part of the Buffalo River during the winter of 1949-50 was undertaken by the Corps of Engineers with an added expenditure of $550,000.

During the past five years, a total of about two million cubic yards of dredged material has been taken from the Buffalo River, Outer Harbor, and the upper Niagara River. From the Buffalo River alone, about 850,000 cubic yards of material has been removed. It consisted of about 80% mud, 15% sand, and the rest small amounts of rock, gravel, and clay. About 550,000 cubic yards of silt, mud, and sand were dredged from the entrance channel to the Buffalo River and the Outer Harbor. This material was composed of about 50% silt, 25% mud, and the rest varying proportions of sand, clay, rock and gravel.

Dredging from the Black Rock Canal and the upper Niagara River has removed a total of 710,000 cubic yards of material. Of this amount, 408,500 cubic yards were removed by Government labor, and consisted of about 45% sand, 25% silt, 20% mud, and 10% gravel. About 300,600 cubic yards of earth and rock have also been removed by Government contract since 1945.

The dredged materials from the Buffalo River, the Buffalo River entrance, the Outer Harbor, and Black Rock Canal are deposited in an area approximately 1.4 miles long and 0.7 mile wide in Lake Erie adjacent to the Bethlehem Steel Company's plant near the mouth of Smokes Creek. The material dredged from the Niagara River downstream from Tonawanda Island is dumped in an area approximately 900 feet square in the Niagara River between the northerly shore of Buckhorn Island on Grand Island and the Federal-maintained channel in the east branch of the Niagara River. No other disposal areas are established or contemplated at the present time.

The raw water quality at the Western New York Water Company has deteriorated appreciably within recent years, particularly in regard to taste and odor. This is due in part to the disposal of dredged material in the Lake Erie dumping grounds near the company's water intake. The water intake line, extending 4,425 feet from shore, approximately parallels the southerly limit of the area, the intake crib being 750 feet distant. The increasing problem of producing a satisfactory water prompted a conference in June 1947 for consideration of relocating this disposal area. The Corps of Engineers indicated that since 1945 they had segregated the dredged material, dumping the rock which usually comes from the Black Rock channel in that part of the designated area closest to the water intake, and the sludge and fine material from the Buffalo River basin and harbor in the area farthest from the intake. Buoys were placed to show the limits of the areas where these materials were to be dumped.

Relocation of the dump area would necessitate transporting the dredged material a greater distance with the resulting curtailment of dredging operations because of limited funds provided for this purpose. The capacity of the dumping grounds is nearly reached and dumping is more difficult each year. The solution of this problem will be the relocation of the dumping area or extension of the water intake of the Western New York Water Company.

Wastes From Navigation

Data obtained from the U. S. Army Corps of Engineers and the individual vessel companies were used to ascertain the extent of vessel passages and the freight and passenger traffic in the eastern end of Lake Erie, the Niagara River, and Lake Ontario.

Sanitary wastes from vessels are confined mostly to navigation channels where discharges occur intermittently, and in harbors when the vessels are in port. While there is some interest in retention tanks among vessel operators, there is no present Federal regulation requiring their installation. Although no freight vessels are so equipped, all of the passenger vessels operating into Buffalo have retention tanks. Sewage stored in the tanks is usually emptied shortly after departure from the harbor area. A mass of sewage is thereby introduced in a limited area on the navigation route, and other vessels following shortly thereafter may draw this contaminated water for domestic purposes.

Pollution contributed by vessels navigating these waters is considered to be significant. One of the passenger ships which plies Lake Erie has a capacity of 2,500 persons and a crew of 225 members. The volume of waste from such large vessels is important. The U. S. Public Health Service estimates the quantity of water used per person to be 30 gallons per day, all of which is discharged as waste in one form or another.

Garbage and rubbish are stored in containers aboard vessels and either dumped overboard in open bodies of water or removed at shore points. The overboard dumping practice pollutes the water and causes nuisances along the shores.

Bilge and ballast water may also be discharged overboard from vessels. Bilge water includes seepage through the hull, and leakage from water lines, pumps and machinery, and contains some lubricating oils and greases. The quantity of this waste is highly variable and it is difficult to estimate the amount of oils discharged with it. Ballast water is used to stabilize the vessel under various operating conditions. On tankers particularly, water is pumped into the empty oil tanks for ballast and discharged overboard before cargo is received. Thus, some oil may be pumped overboard with the ballast water unless oil separation is practiced. Lake water is many times pumped into or discharged from ballast tanks while the vessel is enroute, and this practice may transfer contaminated water taken aboard at one location to a relatively clean area.

Jurisdiction regarding the discharge of pollutants from vessels into these waters is embodied in the River and Harbor Act and the Interstate Quarantine Regulations of the United States Government. The former act prohibits the deposit of any refuse matter, including sewage and oil wastes, from vessels into navigable waters of the United States or into any water which may convey the same into navigable waters. This restriction is more specifically outlined in the Interstate Quarantine Regulations. These regulations state that vessels operating on fresh water lakes or rivers shall not discharge sewage, ballast or bilge water within such areas adjacent to domestic water intakes as are designated by the Surgeon General, Public Health Service. No such areas have been delimited in accordance with these regulations in the Lake Erie-Lake Ontario Section. Local regulations in many areas prohibit the discharge of any wastes from a vessel in the vicinity of water supply intakes and bathing beaches. Such restricted areas should be adequately designated and vessel operators should exert care to insure that these requirements are strictly observed.

Chapter N-VIII

POLLUTION EFFECTS ON BOUNDARY WATER QUALITY

> "And being once amisse growes daily
> wourse and wourse."
> —The Fairie Queene.

The effects of pollution have been measured by bacteriological, chemical and physical examinations. The analytical tests were supplemented by data on municipal water supplies, sewage effluents, and industrial wastes. This information has shown the extent and intensity of pollution both in the boundary waters and tributaries, the changes which take place between the sources of pollution, and the suitability of these waters for the various uses discussed previously.

A total of 4,401 surface water samples was taken during the investigation for bacteriological examinations, 98 for plankton determinations, and 3,279 for chemical tests. The analyses were made in the field laboratories located at St. Catharines, Ontario, and Fort Niagara and Niagara Falls, New York.

Explanation of Laboratory Tests

The analytical determinations used in the survey are listed below. An explanation of each is given as an aid in interpreting the significance of the tests.

Bacteriological Examinations

Bacteriological examinations were limited to the confirmed test for the coliform group of bacteria. These bacteria are normal inhabitants of the intestines of man and other warm-blooded animals, and are discharged in large numbers in human feces. This test is the specific means of approximating the density of organisms of the coliform group which are present in large numbers in sewage and are, in general, relatively few in number in wastes from industries. The results are reported as "most probable number" (M.P.N.) per 100 milliliters. This is now commonly known as the M.P.N. Index.

The water in the main body of Lake Erie, not subject to direct contamination, is relatively free of coliform bacteria, having less than 10 M.P.N. per 100 ml. Raw domestic sewage may contain many million coliform bacteria per 100 ml.

Plankton Determinations

Microscopic examination for free-floating microorganisms known as plankton is useful in explaining causes of taste, odor, and turbidity of waters. In Lake Erie certain plankton are a potential taste and odor hazard to all the water supplies downstream on the Niagara River. These organisms may disintegrate in water, and the volatile oils from their cells may be carried downstream to water supply intakes. Identification of these offending organisms serves as a basis for instituting corrective treatment.

Chlorides

All fresh waters contain chlorides, the normal amount varying in different regions. An increase above normal is an indication of contamination from sewage or industrial wastes. The normal chloride content of Lake Erie water is about 20 parts per million (p.p.m.). Chlorides increase the soap consuming properties of water and adversely affect boiler feed water. They are not removed by the usual water purification processes.

Phenolic Compounds

Phenolic substances in water react with the chlorine, normally applied at water treatment plants, to produce intensely aromatic compounds. These compounds, even when highly diluted, may give a taste and odor to the water which is variously described as medicinal, chemical, or iodoform. Phenolic compounds in low concentrations taint fish and in higher concentrations, are toxic to fish. Normally, water contains no phenolic compounds. In this study phenols and phenolic equivalents were measured by the Gibbs Method with modifications.

Ammonium Compounds

Ammonium compounds include free ammonia and ammonium salts, but they do not include albuminoid ammonia or organic nitrogen. The ammonium ion tends to combine with chlorine to form chloramines in public water supplies and thereby increases the chlorine demand. Ammonium compounds are also toxic to fish. Lake Erie samples showed only trace quantities. Any substantial increase may be attributed to sewage and industrial wastes of an organic type.

Chlorine Demand

The chlorine demand test is an indicator of the amounts of organic matter present in water. It increases with the addition of sewage and other organic pollutants. The difficulty and cost of the chlorination of water are increased where there is a high chlorine demand. Erratic chlorine demand of a water supply source constitutes a public health hazard.

Temperature

The temperature of water influences the solubility of oxygen and the rate of oxidation and self-purification.

Dissolved Oxygen

The amount of dissolved oxygen contained in unpolluted water fluctuates with the temperature. A deficiency of oxygen is replaced by solution of oxygen from the atmosphere. There is a saturation value for each temperature. At 10° Centigrade (50° Fahrenheit) this value is 11.33 p.p.m. of dissolved oxygen. Values below saturation indicate the presence of polluting organic substances which are absorbing oxygen from the water. The extent of this deficiency is one index of the degree of organic pollution. Substantial reduction in dissolved oxygen causes odor nuisances and suffocation of fish.

Biochemical Oxygen Demand (B.O.D.)

The biochemical oxygen demand test indicates the amount of oxygen required for stabilization of the decomposable organic matter. The time and temperature used for this test are 5 days and 20° C., respectively. The B.O.D. of Lake Erie water, unaffected by pollution, approaches zero, while for raw sewage it varies from about 100 to 300 p.p.m.

Turbidity

Turbidity is a measure of the fine suspended solids in water such as silt and finely divided organic matter.

Solids

The analyses for solids include tests for total and suspended solids as well as their volatile constituents. The former measures both the solids in solution and in suspension. The total volatile solids indicate the amount of organic matter present in the water. Both sewage and industrial wastes have significant amounts of solids. Domestic sewage contains about 0.2 pound of suspended solids per capita per day. The solids content of an industrial waste varies with the type of industry.

The effects of suspended solids in water are reflected in the difficulties associated with water purification, deposition in streams, interference with navigation, and injury to the habitat of fish.

Hydrogen Ion Concentration

The hydrogen ion concentration (pH value) of a water indicates its relative acidity or alkalinity. It is a measure of intensity rather than of quantity. A neutral water has a pH of 7.0. Higher values are in the alkaline range, and the lower in the acid range. The pH of Lake Erie water averages about 7.8. Any appreciable departure from this value indicates the addition of acid or alkaline wastes.

Alkalinity

Alkalinity represents the concentration of carbonates, bicarbonates, hydroxides, and occasionally borates, silicates, and phosphates. Industrial waste discharges high in alkalinity generally affect the hardness of the water. Hardness is an economic factor in the use of a water supply either for domestic or industrial purposes.

Oils and Other Ether-Extractable Materials

Oils and other ether-extractable materials include such substances as greases and tars. The presence of these pollutants renders water difficult and sometimes impractical to treat either for industrial or domestic use. Oils make beaches unsightly and waters unfit for bathing. They coat watercraft and are a hazard to waterfowl.

Tastes and Odors

Tastes and odors in water may be associated with the presence of polluting or otherwise objectionable substances such as decomposing organic matter, plankton organisms, and chemical compounds including free chlorine, hydrogen sulfide, and phenols. The determination of the quality and intensity indicates the degree of consumer acceptance of a water supply. These determinations aid in the search for the substances responsible for tastes and odors that may be due to waste discharges or to organic material naturally present in the stream. Odor results are expressed in terms of threshold odor numbers, these values increasing with the amount of odor-free diluting water required to cause disappearance of the odor. Tastes are determined in like manner, and are expressed as the dilution required. Both taste and odor are described by quality or characteristic as well as intensity.

Cyanides

Cyanides are probably the most toxic substances in industrial wastes. Concentrations over 0.05 p.p.m. are not acceptable in a drinking water supply. Low concentrations of between 0.1 and 0.3 p.p.m. are fatal to fish. Cyanides are not natural components of surface waters.

Analytical Results of the 1913 Investigation

Investigation of these waters in 1948-49 revealed that the nature, character, and extent of the pollution found at this time differed materially from the findings of the 1913 survey. In the earlier study, pollution originated almost entirely from sewage.

The industrial development in the Niagara Frontier area at that time was still in its infancy. Power resources at the Falls had not yet attracted the many chemical and allied industries which exist today. Low-cost water transportation has since made the Frontier a manufacturing center and distribution point for a widespread marketing area. Consequently, many of the industries existing today were either not yet established or were operating on a much smaller scale.

The findings in the earlier investigation were based entirely on **B. coli** examinations. The results were expressed in terms of the "Phelps Index" as the approximate number of **B. coli** in 100 ml. of the sample when calculated from the results of single tube dilution tests. The "Coliform group" as recorded in this report may be considered to correspond to the "**B. coli** group" as used formerly. Laboratory procedures have been refined in the intervening years in an effort to obtain greater precision in the estimation of the number of coliform organisms. While comparisons in results of the two investigations can be approximate only, it may be assumed that the M.P.N. figures used in this investigation are 2.4 times greater than numbers which would be given by the "Phelps Index."

In the "Final Report of the International Joint Commission" conditions in the Lake Erie-Lake Ontario Section in 1913 were summarized as follows:

> "The purity of the main body of the lake (Erie) was amply established by examination of its water at several widely separated stations."
>
> "This investigation showed that above Niagara Falls the bulk of the pollution in the river, and due to the discharge of sewage therein, is confined to the marginal waters of the country in which it originates and that the sewage of Buffalo is polluting to a serious extent the available water supplies of the two Tonawandas and the city of Niagara Falls, New York."
>
> "The effect of the pollution of the lower Niagara is to render the river totally unfit for domestic uses unless purified. All of the lower municipalities have been forced to install and operate water purification plants, and the result of their operation shows only too clearly that the use of the water is accompanied by no proper margin of safety."
>
> "The investigation revealed the fact that the waters of Lake Ontario are comparatively free of **B. coli**, with the exception of the 18 mile radius from the mouth of the Niagara River."

Analytical Results of the 1948-1949 Investigation

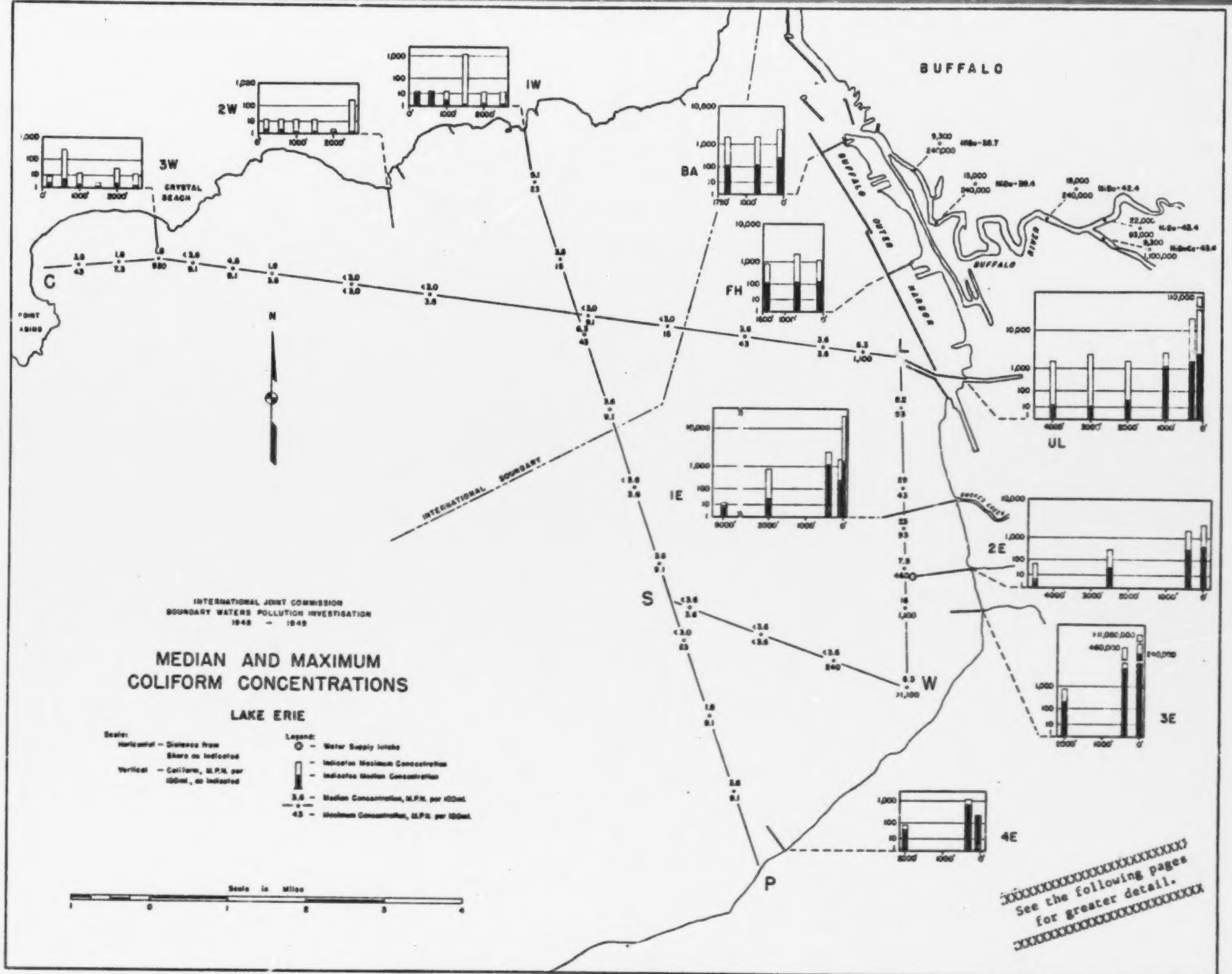
Tables N-17 to N-20, inclusive, present a summary of the analytical results of the bacteriological, chemical, and physical analyses of samples taken during the 1948-1949 survey. Sampling covered the area extending from the eastern end of Lake Erie, through the Niagara River, to a portion of Lake Ontario at the outlet of the Niagara River. The tables give the average values for the chemical and physical tests and the median for bacteriological tests, the maximum and minimum results, and the number of samples analyzed.

A review of the analytical data indicates that the most significant results are the coliform and phenol determinations. Other chemical and physical examinations were conducted routinely but were found not to be sufficiently indicative to denote the trends or paths of pollution. The chloride content of about 20 p.p.m. in Lake Erie was virtually unchanged in this section of the boundary waters. Similarly, the alkalinity of 95 p.p.m. and the pH value of 7.8 found in Lake Erie did not change appreciably. Average turbidity results ranged from 0 to about 5 p.p.m. in Lake Erie and Lake Ontario and as high as 20 p.p.m. in the river, but this difference is not significant. The average B.O.D. values were low, with results ranging between 0 and 2.6 p.p.m. along this stretch of boundary waters. The dissolved oxygen results showed low reduction from saturation, indicating the absence of any oxygen problem . The content of ammonium compounds was uniformly low in the Niagara River but a few high values were noted in Lake Ontario. Primary emphasis is placed on the coliform and phenol determinations in the discussion of the analytical results which follows.

Lake Erie

The summary of analytical results for samples taken in Buffalo Outer Harbor and the eastern end of Lake Erie is presented in table N-17 (see pages 263 to 269). The coliform results are plotted in figure N-3 and the phenol data in figure N-4. In Buffalo Outer Harbor, median coliform M.P.N. values ranged from 11 to 4,600 per 100 ml., with a maximum value of 110,000. Phenol determinations at the southern end of the harbor showed average results as high as 49 parts per billion (p.p.b.) and a maximum of 200 p.p.b. Biochemical oxygen demand results were relatively low, the highest average value being 1.5 p.p.m. Average total iron results on a range at the south end of the harbor varied from 1.0 to 2.8 p.p.m. with a maximum of 3.5 p.p.m.

The water along the United States shore, south of the outer harbor, shows pollution from both sewage and industrial wastes. Coliform median M.P.N. values ranged from 430 to 240,000 per 100 ml. with a maximum value greater than 11,000,000 at one shore sampling point. Offshore 2,500 feet, the results show a substantial reduction in coliforms with the medians varying from 43 to 390. Phenol results along shore were also high; a maximum of


INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 – 1948
MEDIAN AND MAXIMUM
COLIFORM CONCENTRATIONS
LAKE ERIE
Scale:
Horizontal – Distance from Shore as Indicated
Vertical – Coliform, M.P.N. per 100ml., as Indicated
Legend:
○ – Water Supply Intake
– Indicates Maximum Concentration
– Indicates Median Concentration
3.6 – Median Concentration, M.P.N. per 100ml.
43 – Maximum Concentration, M.P.N. per 100ml.
Scale in Miles
1 0 1 2 3 4
N
BUFFALO
BUFFALO OUTER HARBOR
BUFFALO RIVER
CRYSTAL BEACH
POINT ABINO
INTERNATIONAL BOUNDARY
C
S
L
W
P
3W
2W
1W
BA
FH
UL
1E
2E
3E
4E

XXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXX

Figure N-3

263-a

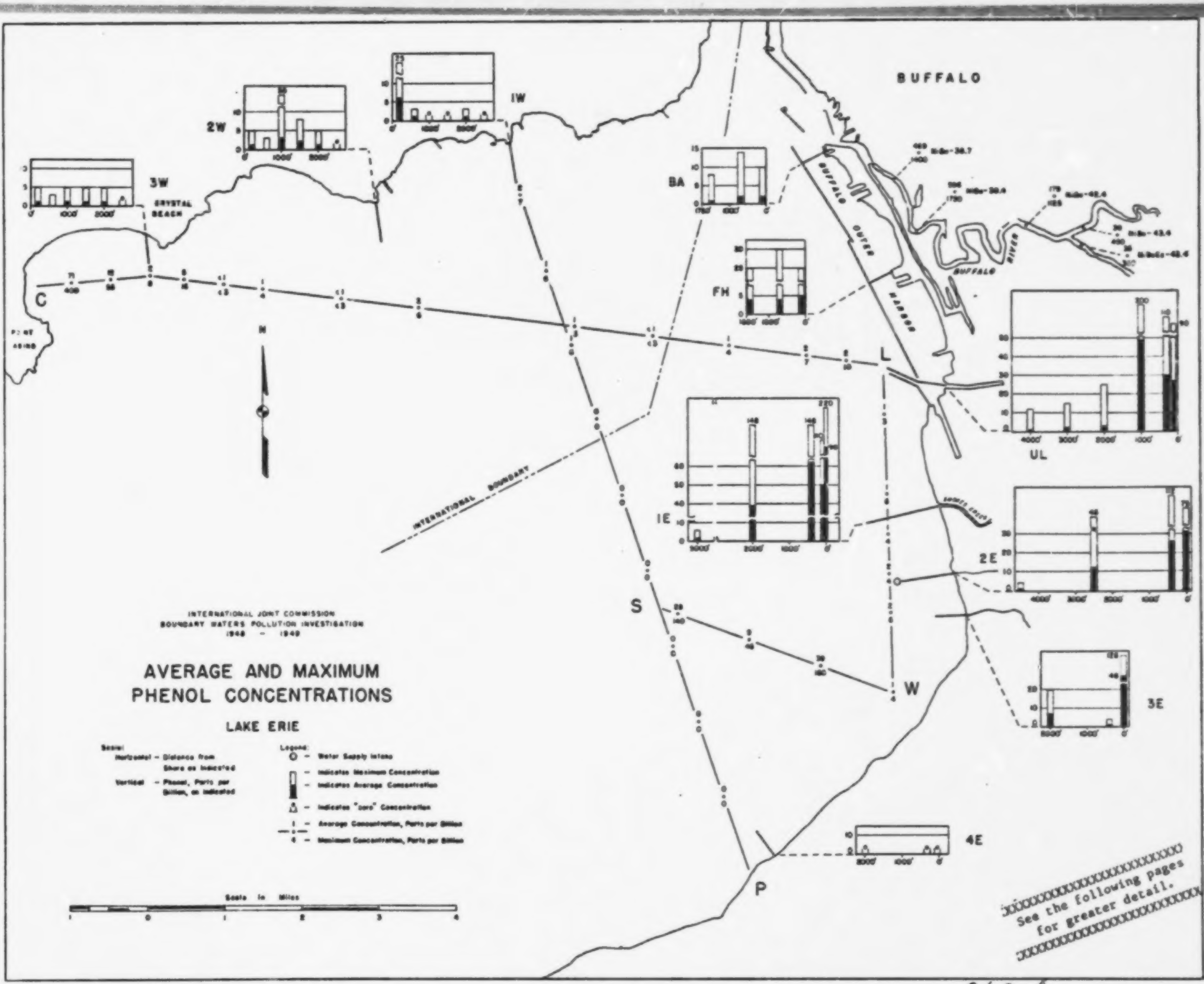

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 - 1949
AVERAGE AND MAXIMUM
PHENOL CONCENTRATIONS
LAKE ERIE
Scale:
Horizontal - Distance from Shore as Indicated
Vertical - Phenol, Parts per Billion, as Indicated
Legend:
○ - Water Supply Intake
- Indicates Maximum Concentration
- Indicates Average Concentration
△ - Indicates "zero" Concentration
- Average Concentration, Parts per Billion
- Maximum Concentration, Parts per Billion
Scale in Miles
1
0
1
2
3
4
BUFFALO
BUFFALO OUTER HARBOR
BUFFALO RIVER
INTERNATIONAL BOUNDARY
CRYSTAL BEACH
POINT ABINO
N
C
L
S
W
P
3W
2W
1W
BA
FH
UL
1E
2E
3E
4E

Figure N-4

See the following pages
for greater detail.

263-4

TABLE N-17—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ERIE

Sampling Range and Location	Station (Feet)		Coliforms M.P.M. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm	Total Iron ppm
	0			United States Shore									
BA. A range in Buffalo Harbor from the United States Coast Guard slip to Anchorage Light on the breakwater	100	Median	430										
		Average		21	2	0.04	10	10.9	0.8	11	8.0	88	....
		Maximum	4,600	25	10	0.20	23	12.9	1.3	24	8.4	98	....
		Minimum	36	17	0	0	2	8.2	0.4	2	7.4	59	....
		No. of Samples	24	16	24	18	20	17	14	20	20	15	....
	700	Median	190										
		Average		21	2	0.02	12	10.3	1.0	9	8.0	91	....
		Maximum	2,400	25	14	0.14	25	13.1	3.0	22	8.4	98	....
		Minimum	23	18	0	0	2	6.0	0.4	1	7.6	85	....
		No. of Samples	26	23	26	23	27	24	21	27	26	22	....
	1,500	Median	120										
		Average		21	1	0.01	10	11.0	0.8	11	8.0	92	....
		Maximum	2,400	25	8	0.08	22	13.1	1.4	22	8.4	98	....
		Minimum	<3.6	18	0	0	2	8.1	0.3	1	7.5	87	....
		No. of Samples	24	16	24	18	20	17	15	20	20	15	....
	0			United States Shore									
FH. A range in Buffalo Harbor from the north end of the Ford Company dock to the breakwater	100	Median	220										
		Average		21	5	0.04	12	10.6	0.8	10	8.1	93	....
		Maximum	1,100	26	25	0.24	23	13.0	1.3	23	8.5	97	....
		Minimum	43	18	0	0	2	8.4	0.6	2	7.7	85	....
		No. of Samples	16	11	16	12	14	12	9	14	14	10	....
	700	Median	180										
		Average		21	4	0.04	14	10.1	1.1	8	8.1	92	....
		Maximum	2,400	26	30	0.20	24	13.2	5.5	20	8.6	96	....
		Minimum	43	17	0	0	2	8.2	0.5	1	7.5	86	....
		No. of Samples	18	16	18	15	19	17	15	19	18	15	....
	1,500	Median	120										
		Average		21	4	0.04	12	10.5	0.8	12	8.1	93	....
		Maximum	930	24	25	0.16	23	13.2	1.7	38	8.6	96	....
		Minimum	<3.0	18	0	0	2	8.3	0.3	1	7.6	87	....
		No. of Samples	16	11	16	12	14	11	8	14	14	10	....
	0			United States Shore									
UL. A range in Buffalo Harbor from the mouth of Union Canal through south entrance to a point 300 feet west of South Pier Light	100	Median	4,600										
		Average		23	27	0.57	18	8.2	1.5	26	8.0	101	2.8
		Maximum	110,000	28	90	1.5	30	9.6	6.7	107	8.5	130	2.5
		Minimum	93	18	0	0.12	2	6.5	0.3	2	7.5	94	2.2
		No. of Samples	21	20	23	19	23	22	19	23	23	19	3
	300	Median	2,400										
		Average		22	30	0.41	14	9.0	1.5	20	8.0	97	1.5
		Maximum	24,000	26	110	1.1	24	11.2	3.6	47	8.4	101	1.6
		Minimum	430	18	0	0.12	3	6.8	0.5	5	7.5	88	1.4
		No. of Samples	15	13	16	15	16	15	14	16	16	12	3
	1,000	Median	1,900										
		Average		22	49	0.33	15	9.4	1.2	13	8.1	94	1.1
		Maximum	4,600	24	200	1.1	25	11.8	1.9	26	8.4	99	1.4
		Minimum	230	19	0	0	4	7.6	0.5	2	7.6	87	1.0
		No. of Samples	22	17	23	16	20	19	17	19	20	16	3
	2,000	Median	41										
		Average		20	3	0.02	13	10.5	0.8	8	8.1	94	1.0
		Maximum	2,400	25	25	0.16	23	13.4	1.9	22	8.5	96	1.2
		Minimum	<3.0	18	0	0	3	8.4	0.2	1	7.7	87	0.7
		No. of Samples	22	15	23	16	18	17	14	18	18	14	2
	3,000	Median	11										
		Average		20	2	0	12	10.8	0.9	9	8.1	93	....
		Maximum	4,600	23	15	0.04	23	13.3	1.8	27	8.5	98	....
		Minimum	<3.0	18	0	0	2	8.6	0.2	1	7.7	84	....
		No. of Samples	17	14	18	15	17	12	11	17	17	13	....

Table N-17—Summary of Average Analytical Results—Lake Erie—Continued

Sampling Range and Location	Station (Feet)		Coliforms M.P.M. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm	Total Iron ppm
UL. (Continued)	4,000	Median	23	....	....	....	....	....	....	....	....	....	
		Average	....	20	1	0.01	13	10.3	0.8	8	8.1	93	....
		Maximum	2,400	25	12	0.08	23	13.3	2.3	25	8.5	98	....
		Minimum	<3.0	14	0	0	2	8.3	0.2	1	7.7	87	....
		No. of Samples	21	17	22	17	20	15	14	20	20	16	....
	(Miles)												
	0			South	Pier	Light							
LW. A range south from South Pier Light over the Western New York Water Company intake, to point W, 1½ miles south of the intake	0.5	Median	8.2	....	....	....	....	....	....	....	....	....	
		Average	....	19	1	0	14	12.4	1.2	3	8.4	94	....
		Maximum	93	23	3	0.01	21	13.0	1.6	5	8.6	96	....
		Minimum	<3.0	16	0	0	8	11.8	0.8	1	8.1	93	....
		No. of Samples	4	5	5	5	5	2	2	5	5	5	....
	1.5	Median	29	....	....	....	....	....	....	....	....	....	
		Average	....	20	1	0.01	14	12.4	1.3	4	8.3	93	....
		Maximum	43	23	6	0.01	21	13.0	1.6	5	8.5	96	....
		Minimum	<3.0	17	0	0	8	11.7	1.0	2	8.1	92	....
		No. of Samples	4	5	5	5	5	2	2	5	5	5	....
	2.0	Median	23	....	....	....	....	....	....	....	....	....	
		Average	....	21	1	0	15	12.5	1.6	4	8.3	93	....
		Maximum	93	23	4	0.01	21	13.0	1.8	6	8.5	96	....
		Minimum	0	18	0	0	8	12.0	1.4	2	8.1	90	....
		No. of Samples	5	5	5	5	5	2	2	5	5	5	....
	2.5 (Intake)	Median	7.5	....	....	....	....	....	....	....	....	....	
		Average	....	20	2	0.01	15	12.5	1.2	4	8.3	94	....
		Maximum	460	22	4	0.04	21	13.0	1.6	6	8.5	95	....
		Minimum	<3.0	18	0	0	8	12.0	0.8	2	7.7	92	....
		No. of Samples	4	5	5	5	5	2	2	5	5	5	....
	3.0	Median	16	....	....	....	....	....	....	....	....	....	
		Average	....	20	2	0	15	12.5	1.0	4	8.3	94	....
		Maximum	1,100	22	6	0.01	21	12.9	1.3	5	8.5	96	....
		Minimum	<3.0	18	0	0	9	12.0	0.6	2	7.9	92	....
		No. of Samples	4	5	5	5	5	2	2	5	5	5	....
	4.0			Point	W								
	4.0	Median	6.3	....	....	....	....	....	....	....	....	....	
		Average	....	20	1	0.01	15	12.5	1.2	3	8.3	93	....
		Maximum	>1,100	23	4	0.06	21	12.9	1.8	6	8.7	96	....
		Minimum	<3.6	18	0	0	9	12.0	0.6	2	7.9	91	....
		No. of Samples	4	5	5	5	5	2	2	5	5	5	....
	(Feet)												
	0			United	States	Shore							
1E. A range from the mouth of Smokes Creek, perpendicular to the United States shore	0	Median	2,300	....	....	....	....	....	....	....	....	....	
		Average	....	22	98	0.69	19	5.7	10.0	27	6.6	66	....
		Maximum	24,000	31	220	1.80	22	8.8	23.0	53	7.5	108	....
		Minimum	430	17	10	0.12	16	0	0.9	6	4.5	0	....
		No. of Samples	7	7	7	7	7	7	7	7	7	7	....
	100	Median	430	....	....	....	....	....	....	....	....	....	
		Average	....	21	50	0.16	18	8.0	3.1	30	7.3	81	....
		Maximum	2,400	24	110	0.24	21	9.5	7.6	64	7.8	93	....
		Minimum	150	19	Trace	0.04	16	7.0	0.6	6	6.8	67	....
		No. of Samples	3	3	3	3	3	3	3	3	3	3	....
	400	Median	1,415	....	....	....	....	....	....	....	....	....	
		Average	....	20	62	0.16	17	8.1	1.5	20	7.4	84	....
		Maximum	4,600	25	148	0.24	20	9.5	4.1	74	7.7	93	....
		Minimum	23	16	3	0.01	16	6.8	0.1	4	6.8	67	....
		No. of Samples	6	6	6	6	6	5	5	6	6	6	....

TABLE N-17—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ERIE—Continued

Sampling Range and Location	Station (Feet)		Coliforms M.P.M. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_1 ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm	Total Iron ppm
1E. (Continued)	2,000	Median	43	....	....	....	....	....	....	....	....	....	....
		Average	....	19	39	0.02	16	9.5	0.5	5	7.9	94	....
		Maximum	930	22	148	0.06	20	10.3	0.9	7	8.3	96	....
		Minimum	<3.0	17	0	0	12	8.7	0.2	3	7.3	91	....
		No. of Samples	5	6	6	6	6	6	6	6	6	6	....
	5,000	Median	9.1	....	....	....	....	....	....	....	....	....	....
		Average	....	19	2	0	15	9.7	0.5	3	8.1	95	....
		Maximum	23	22	6	Trace	18	10.6	0.8	4	8.4	97	....
		Minimum	<3.0	17	0	0	12	8.5	0.2	2	7.7	94	....
		No. of Samples	5	5	5	5	5	5	5	5	5	5	....
	0			United States Shore									
2E. A range from the mouth of drainage ditch at south boundary of Bethlehem Steel property, perpendicular to United States shore	0	Median	680	....	....	....	....	....	....	....	....	....	....
		Average	....	31	74	0.89	25	4.7	8.1	47	5.6	....	....
		Maximum	4,300	75	150	3.2	28	9.6	>21	134	7.1	79	....
		Minimum	<3.0	18	3	0.24	20	0	3.1	8	3.0	Acidity 2,348	....
		No. of Samples	8	6	8	8	8	8	8	8	8	7	....
	400	Median	490	....	....	....	....	....	....	....	....	....	....
		Average	....	20	26	0.04	17	8.8	0.8	8	7.6	90	....
		Maximum	2,400	23	112	0.10	21	9.3	1.1	15	8.1	95	....
		Minimum	43	17	0	0	16	8.4	0.3	4	7.2	85	....
		No. of Samples	6	6	6	6	6	6	6	6	6	6	....
	2,500	Median	43	....	....	....	....	....	....	....	....	....	....
		Average	....	19	12	0.01	15	9.5	0.5	5	7.9	93	....
		Maximum	430	21	45	0.02	18	10.0	0.8	8	8.1	96	....
		Minimum	7.3	17	0	Trace	12	9.0	0.3	3	7.3	87	....
		No. of Samples	5	5	5	5	5	5	5	5	5	5	....
	4,500	Median	6.3	....	....	....	....	....	....	....	....	....	....
		Average	....	20	1	0.05	16	9.4	0.4	3	8.0	94	....
		Maximum	75	21	4	0.28	20	10.3	0.5	3	8.3	96	....
		Minimum	3	17	0	0	12	8.8	0.2	2	7.5	90	....
		No. of Samples	6	6	6	6	6	6	6	6	6	6	....
	0			United States Shore									
3E. A range from the mouth of Rush Creek, perpendicular to United States shore	0	Median	240,000	....	....	....	....	....	....	....	....	....	....
		Average	....	51	48	5.4	15	2.3	21.1	32	7.2	211	....
		Maximum	11,000,000	72	128	19.0	19	7.6	69	93	7.6	277	....
		Minimum	910	18	4	0.16	11	0	6.3	5	6.7	158	....
		No. of Samples	7	7	7	7	7	7	6	7	7	7	....
	400	Median	5,520	....	....	....	....	....	....	....	....	....	....
		Average	....	21	1	0.09	16	9.4	0.6	4	7.9	93	....
		Maximum	460,000	22	4	0.30	18	9.9	0.8	6	8.1	94	....
		Minimum	<30	18	0	0	12	9.0	0.3	2	7.5	90	....
		No. of Samples	4	4	4	4	4	4	4	4	4	4	....
	2,000	Median	390	....	....	....	....	....	....	....	....	....	....
		Average	....	20	7	0.02	15	9.4	0.6	5	8.0	93	....
		Maximum	930	22	20	0.06	18	10.1	1.1	10	8.1	95	....
		Minimum	9.1	17	0	0	11	8.8	0.3	3	7.9	91	....
		No. of Samples	5	5	5	5	5	5	5	5	5	5	....
	0			United States Shore									
4E. A range from the Wanakah Water Company property perpendicular to United States shore	50	Median	430	....	....	....	....	....	....	....	....	....	....
		Average	....	17	0	0	16	10.3	0.4	3	8.1	93	....
		Maximum	430	18	0	0	17	10.3	0.4	3	8.1	94	....
		Minimum	430	16	0	0	14	10.2	0.4	2	8.1	92	....
		No. of Samples	2	2	2	2	2	2	2	2	2	2	....
	325	Median	870	....	....	....	....	....	....	....	....	....	....
		Average	....	18	0	0	16	10.0	0.4	3	8.1	93	....
		Maximum	1,500	19	0	0	17	10.2	0.4	3	8.1	93	....
		Minimum	240	17	0	0	15	9.7	0.3	2	8.1	93	....
		No. of Samples	2	2	2	2	2	2	2	2	2	2	....

Table N-17—Summary of Average Analytical Results—Lake Erie—Continued

Sampling Range and Location	Station (Feet)		Coliforms M.P.M. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N₂ ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm	Total Iron ppm
4E. (Continued)	2,000	Median	68										
		Average	....	17	0	0	17	9.4	0.2	3	8.1	96	....
		Maximum	93	19	0	0	18	9.4	0.2	3	8.1	97	....
		Minimum	43	15	0	0	15	9.3	0.2	2	8.1	94	....
		No. of Samples	2	2	2	2	2	2	2	2	2	2	....
	0			Canadian Shore									
1W. A range from Rose Hill Point, perpendicular to Canadian shore	200	Median	12										
		Average	....	....	6	....	....	....	....	....	....	....	....
		Maximum	23	....	25	....	....	....	....	....	....	....	....
		Minimum	<3.0	....	0	....	....	....	....	....	....	....	....
		No. of Samples	4	....	4	....	....	....	....	....	....	....	....
	600	Median	16										
		Average	....	21	1	0	16	9.6	1.7	2	8.1	91	....
		Maximum	23	24	3	0	25	10.3	4.0	5	8.2	94	....
		Minimum	3.6	17	0	0	11	8.5	0.2	1	8.0	90	....
		No. of Samples	6	6	6	3	6	6	5	6	5	6	....
	1,000	Median	4.9										
		Average	....	....	0	....	....	....	....	....	....	....	....
		Maximum	23	....	0	....	....	....	....	....	....	....	....
		Minimum	<3.0	....	0	....	....	....	....	....	....	....	....
		No. of Samples	6	....	6	....	....	....	....	....	....	....	....
	1,500	Median	1.5										
		Average	....	21	0	0	15	9.9	1.6	2	8.1	89	....
		Maximum	>1,500	24	0	0	20.5	11.3	2.6	4	8.2	90	....
		Minimum	<3.0	18	0	0	11	8.4	0.3	1	8.1	88	....
		No. of Samples	6	5	6	2	5	5	4	5	4	5	....
	2,000	Median	1.8										
		Average	....	....	1	....	....	....	....	....	....	....	....
		Maximum	23	....	3	....	....	....	....	....	....	....	....
		Minimum	<3.0	....	0	....	....	....	....	....	....	....	....
		No. of Samples	6	....	6	....	....	....	....	....	....	....	....
	2,500	Median	<3.0										
		Average	....	24	0	0.01	23	8.6	2.6	1	8.1	91	....
		Maximum	23	24	0	0.02	25	8.7	5.0	1	8.1	92	....
		Minimum	<3.0	23	0	0	21	8.5	0.2	1	8.1	90	....
		No. of Samples	5	2	5	2	2	2	2	2	2	2	....
	0			Canadian Shore									
2W. A range from Windmill Point perpendicular to Canadian shore	200	Median	3.3										
		Average	....	....	1	0.02	10	10.6	0.5	5	8.0	....	....
		Maximum	23	....	5	0.03	10	10.7	0.5	8	8.1	....	....
		Minimum	<3.0	....	0	0	10	10.4	0.4	2	7.9	....	....
		No. of Samples	6	....	6	2	2	2	2	2	2	....	....
	600	Median	3.6										
		Average	....	21	0	0	15	9.7	1.2	2	8.1	90	....
		Maximum	23	24	3	0	25	10.6	2.9	5	8.1	92	....
		Minimum	<3.0	17	0	0	10	8.4	0.3	1	7.9	86	....
		No. of Samples	8	6	8	5	8	8	7	8	7	6	....
	1,000	Median	<3.0										
		Average	....	....	3	0	10	10.5	0.6	3	8.0	....	....
		Maximum	23	....	20	0	10	10.6	0.7	4	8.1	....	....
		Minimum	<3.0	....	0	0	10	10.3	0.4	2	7.9	....	....
		No. of Samples	8	....	8	2	2	2	2	2	2	....	....
	1,500	Median	<3.0										
		Average	....	20	2	0	14	9.9	0.9	3	8.1	89	....
		Maximum	23	23	8	0	20	10.5	2.0	5	8.3	92	....
		Minimum	<3.0	17	0	0	10	9.3	0.4	1	7.9	84	....
		No. of Samples	8	5	8	4	7	7	6	7	6	5	....
	2,000	Median	1.8										
		Average	....	....	1	0	10	10.4	0.6	3	8.0	....	....
		Maximum	3.6	....	5	0	10	10.5	0.6	4	8.1	....	....
		Minimum	<3.0	....	0	0	10	10.2	0.5	2	7.9	....	....
		No. of Samples	8	....	8	2	2	2	2	2	2	....	....

TABLE N-17—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ERIE—Continued

Sampling Range and Location	Station (Feet)		Coliforms M.P.M. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm	Total Iron ppm
2W. (Continued)	2,500	Median	<3.0	....	....	....	....	....	....	....	....	....	....
		Average	....	24	0	0	22	8.7	1.0	1	8.2	90	....
		Maximum	240	24	0	0	24	8.7	1.5	1	8.3	90	....
		Minimum	<3.0	23	0	0	20	8.6	0.5	1	8.1	90	....
		No. of Samples	5	2	5	2	2	2	2	2	2	2	....
	0			Canadian Shore									
3W. A range from Crystal Beach Pier, perpendicular to Canadian shore	200	Median	3.6	....	....	....	....	....	....	....	....	....	....
		Average	....	25	1	0	15	9.9	0.7	2	8.1	92	....
		Maximum	9.1	25	5	0	25	10.7	1.2	3	8.3	92	....
		Minimum	<3.0	25	0	0	10	8.5	0.5	2	7.9	92	....
		No. of Samples	7	1	7	3	3	3	3	3	3	1	....
	600	Median	6.3	....	....	....	....	....	....	....	....	....	....
		Average	....	21	0	0	15	9.8	0.7	2	8.1	90	....
		Maximum	460	24	3	0.02	25	10.6	1.5	5	8.3	92	....
		Minimum	<3.0	17	0	0	10	8.7	0.3	1	7.9	90	....
		No. of Samples	8	8	8	5	8	8	7	8	6	6	....
	1,000	Median	<3.6	....	....	....	....	....	....	....	....	....	....
		Average	....	....	1	0	10	10.5	0.5	3	8.0	....	....
		Maximum	23	....	5	0	10	10.6	0.5	3	8.1	....	....
		Minimum	<3.0	....	0	0	10	10.3	0.4	2	7.9	....	....
		No. of Samples	8	...	8	2	2	2	2	2	2	....	....
	1,500	Median	<3.0	....	....	....	....	....	....	....	....	....	....
		Average	....	21	1	0	14	9.8	0.5	3	8.1	89	....
		Maximum	3.6	23	5	0	20	10.5	1.4	5	8.3	92	....
		Minimum	<3.0	18	0	0	10	8.9	0	1	7.9	85	....
		No. of Samples	8	5	8	4	7	7	7	7	6	5	....
	2,000	Median	3.6	....	....	....	....	....	....	....	....	....	....
		Average	....	....	1	0	10	10.4	0.4	3	8.0	....	....
		Maximum	43	....	5	0	10	10.5	0.4	3	8.1	....	....
		Minimum	<3.0	....	0	0	10	10.2	0.3	2	7.9	....	....
		No. of Samples	8	....	7	2	2	2	2	2	2	....	....
	2,500	Median	<3.0	....	....	....	....	....	....	....	....	....	....
		Average	....	24	0	0	23	8.6	0.5	1	8.1	89	....
		Maximum	23	24	0	0	25	8.8	0.7	1	8.1	90	....
		Minimum	<3.0	23	0	0	20	8.3	0.2	1	8.1	88	....
		No. of Samples	5	2	5	2	2	2	2	2	1	2	....
	(Miles)												
	0				United States Shore								
P-1W. A range from point "P" on the United States shore through Seneca Shoal light to Rose Hill Point, Ontario (1W)	1.0	Median	3.6	....	....	....	....	....	....	....	....	....	....
		Average	....	24	0	0	23	8.6	1.0	1	8.3	90	....
		Maximum	9.1	25	0	0	24.5	8.9	1.3	1	8.5	92	....
		Minimum	<3.0	22	0	0	20	8.3	0.4	1	8.1	88	....
		No. of Samples	4	4	4	4	4	4	4	4	4	4	....
	2.0	Median	1.8	....	....	....	....	....	....	....	....	....	....
		Average	....	23	0	0	22	8.7	0.7	1	8.2	91	....
		Maximum	9.1	25	0	0	24	9.0	1.5	1	8.5	94	....
		Minimum	<3.0	22	0	0	19.5	8.3	0.3	1	8.1	88	....
		No. of Samples	4	4	4	4	4	4	4	4	4	4	....
	3.0	Median	<3.0	....	....	....	....	....	....	....	....	....	....
		Average	....	26	0	0	23.5	8.6	1.6	1	8.2	88	....
		Maximum	23	26	0	0	23.5	8.6	1.6	1	8.2	88	....
		Minimum	<3.0	26	0	0	23.5	8.6	1.6	1	8.2	88	....
		No. of Samples	5	1	5	1	1	1	1	1	1	1	....
	3.5				Seneca Shoal								
	4.0	Median	3.6	....	....	....	....	....	....	....	....	....	....
		Average	....	....	0	....	....	....	....	....	....	....	....
		Maximum	9.1	....	0	....	....	....	....	....	....	....	....
		Minimum	<3.0	....	0	....	....	....	....	....	....	....	....
		No. of Samples	5	....	5	....	....	....	....	....	....	....	....

TABLE N-17—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ERIE—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.M. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm	Total Iron ppm
P-1W (Continued)	5.0	Median	<3.6	....	....	....	....	....	....	....	....	....	
		Average	....	23	0	0	23	8.6	1.0	1	8.3	89	....
		Maximum	3.6	24	0	0	24	9.0	1.6	1	8.4	90	....
		Minimum	<3.0	23	0	0	21	8.4	0.7	1	8.1	88	....
		No. of Samples	5	3	5	3	3	3	3	3	3	3	....
	5.8			International Boundary									
	6.0	Median	3.6	....	....	....	....	....	....	....	....	....	
		Average	....	25	0	0	18	9.6	0.9	1	8.2	90	....
		Maximum	9.1	25	0	0	18	9.6	0.9	1	8.2	90	....
		Minimum	<3.0	25	0	0	18	9.6	0.9	1	8.2	90	....
		No. of Samples	6	1	6	1	1	1	1	1	1	1	....
	7.0	Median	6.3	....	....	....	....	....	....	....	....	....	
		Average	....	23	1	0	23.5	8.3	1.5	1	8.2	90	....
		Maximum	43	23	6	0	23.5	8.3	1.5	1	8.2	90	....
		Minimum	<3.0	23	0	0	23.5	8.3	1.5	1	8.2	90	....
		No. of Samples	6	1	6	1	1	1	1	1	1	1	....
	8.0	Median	3.6	....	....	....	....	....	....	....	....	....	
		Average	....	23	1	0	22	8.9	0.8	1	8.4	91	....
		Maximum	15	24	6	0	24.5	9.5	1.2	1	8.5	92	....
		Minimum	<3.0	22	0	0	19.5	8.3	0.5	1	8.2	90	....
		No. of Samples	7	4	7	4	4	4	4	4	4	4	....
	9.0	Median	9.1	....	....	....	....	....	....	....	....	....	
		Average	....	24	2	0	23	8.6	1.1	1	8.2	91	....
		Maximum	23	24	7	0	24.5	9.0	1.7	1	8.4	92	....
		Minimum	<3.0	23	0	0	20	8.3	0.4	1	8.1	90	....
		No. of Samples	6	4	6	4	4	4	4	4	4	4	....
	0			United States Shore									
	0.4			Point W									
WS. A range from point "W" to the Seneca Shoal light on bearing N 71° W	1.4	Median	<3.6	....	....	....	....	....	....	....	....	....	
		Average	....	20	39	0	15	12.4	1.2	3	8.4	94	....
		Maximum	240	23	160	0.01	21	12.9	1.7	6	8.6	96	....
		Minimum	<3.0	18	0	0	9	11.8	0.6	2	8.1	92	....
		No. of Samples	4	5	5	5	5	2	2	5	5	5	....
	2.4	Median	<3.6	....	....	....	....	....	....	....	....	....	
		Average	....	21	9	0	15	12.4	1.1	3	8.4	94	....
		Maximum	<3.6	23	45	0.01	21	12.8	1.4	6	8.6	97	....
		Minimum	<3.0	18	0	0	8	11.9	0.7	2	8.1	92	....
		No. of Samples	4	5	5	5	5	2	2	5	5	5	....
	3.4	Median	<3.6	....	....	....	....	....	....	....	....	....	
		Average	....	20	28	0	15	12.3	1.2	3	8.4	95	....
		Maximum	3.6	23	140	0.01	21	12.3	1.2	5	8.6	96	....
		Minimum	<3.0	18	0	0	8	12.3	1.1	2	8.1	93	....
		No. of Samples	4	5	5	5	5	2	2	5	5	5	....
	3.8			Seneca Shoal									
	0			South Pier Light									
LC. A range from South Pier Light to Crystal Beach, Ontario, thence along beach for 1½ miles on a line about 1,000 feet from shore	0.5	Median	6.3	....	....	....	....	....	....	....	....	....	
		Average	....	23	2	0.01	15	10.3	1.4	6	8.2	93	....
		Maximum	1,100	26	10	0.06	23	13.4	3.3	18	8.5	96	....
		Minimum	<3.0	18	0	0	10	7.9	0.4	2	7.7	86	....
		No. of Samples	10	6	11	7	8	5	5	8	8	6	....
	1.0	Median	3.6	....	....	....	....	....	....	....	....	....	
		Average	....	22	2	....	23	8.5	0.7	1	8.3	94	....
		Maximum	3.6	22	7	....	23	8.5	0.7	1	8.3	94	....
		Minimum	3.0	22	Trace	....	23	8.5	0.7	1	8.3	94	....
		No. of Samples	3	1	3	....	1	1	1	1	1	1	....

TABLE N-17—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ERIE—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.M. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_3 ppm	Temp. ° C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm	Total Iron ppm
LC (Continued)	2.0	Median	3.6	....	....	....	....	....	....	....	....	....	....
		Average	....	21	1	0	15	11.8	1.4	3	8.3	92	....
		Maximum	43	23	4	0.01	23	13.4	1.8	6	8.6	96	....
		Minimum	<3.0	18	0	0	10	10.8	1.0	1	7.9	83	....
		No. of Samples	10	5	10	6	7	3	4	7	7	5	....
	2.8			Inter	nation	al Bou	ndary						
	3.0	Median	<3.0	....	....	....	....	....	....	....	....	....	....
		Average	....	23	Trace	0	22	8.6	0.8	1	8.1	92	....
		Maximum	15	23	Trace	0	23	8.7	1.8	1	8.3	96	....
		Minimum	<3.0	21	0	0	20	8.4	0.2	1	7.8	90	....
		No. of Samples	5	4	5	2	4	3	4	4	4	4	....
	4.0	Median	<3.0	....	....	....	....	....	....	....	....	....	....
		Average	....	21	1	0	13	12.1	1.1	4	8.3	93	....
		Maximum	9.1	22	3	0.01	20	13.7	1.7	7	8.6	95	....
		Minimum	<3.0	17	0	0	10	10.9	0.6	1	7.9	87	....
		No. of Samples	8	4	8	6	6	3	3	6	6	4	....
	6.0	Median	<3.0	....	....	....	....	....	....	....	....	....	....
		Average	....	21	2	0.01	13	11.7	0.8	3	8.2	94	....
		Maximum	3.6	22	6	0.03	20	13.2	1.1	5	8.5	97	....
		Minimum	<3.0	18	0	0	10	10.9	0.4	2	7.9	88	....
		No. of Samples	8	4	8	6	6	3	3	6	6	4	....
	7.0	Median	<3.0	....	....	....	....	....	....	....	....	....	....
		Average	....	19	Trace		20	8.9	0.6	2	....	90	....
		Maximum	<3.0	19	Trace	....	20	8.9	0.6	2	....	90	....
		Minimum	<3.0	19	0	....	20	8.9	0.6	2	....	90	....
		No. of Samples	2	1	2	....	1	1	1	1	....	1	....
	8.0	Median	1.8	....	....	....	....	....	....	....	....	....	....
		Average	....	20	1	0	13	10.9	0.6	3	8.2	94	....
		Maximum	3.6	21	4	Trace	20	10.9	0.8	4	8.6	94	....
		Minimum	<3.0	18	0	0	10	10.8	0.3	2	7.9	94	....
		No. of Samples	8	3	7	5	5	2	2	5	5	3	....
	8.5	Median	4.5	....	....	....	....	....	....	....	....	....	....
		Average	....	22	Trace	....	23	8.7	0.7	2	8.3	92	....
		Maximum	9.1	23	Trace	....	25	8.8	0.8	2	8.3	94	....
		Minimum	<3.0	21	0	....	20	8.5	0.6	1	8.3	90	....
		No. of Samples	2	2	2	....	2	2	2	2	1	2	....
	9.0	Median	<3.6	....	....	....	....	....	....	....	....	....	....
		Average	....	21	5	0	15	11.0	1.4	3	8.2	94	....
		Maximum	9.1	23	16	0.01	25	13.4	2.3	5	8.6	96	....
		Minimum	<3.0	18	0	0	10	8.8	0.8	2	7.9	87	....
		No. of Samples	8	5	8	6	7	4	4	7	7	5	....
	9.5				Jun	ction	with	Range	3W				
	9.5	Median	1.8	....	....	....	....	....	....	....	....	....	....
		Average	....	21	2	0	13	11.4	0.7	3	3.2	95	....
		Maximum	930	22	8	0.01	20	12.6	0.8	6	8.5	98	....
		Minimum	<3.0	18	0	0	10	10.6	0.5	2	7.9	92	....
		No. of Samples	6	4	6	6	6	3	3	6	6	4	....
	10.0	Median	1.8	....	....	....	....	....	....	....	....	....	....
		Average	....	20	12	0	13	11.7	0.7	3	8.2	94	....
		Maximum	7.3	21	55	0.01	20	13.1	0.8	4	8.6	97	....
		Minimum	<3.0	18	0	0	10	10.9	0.5	2	7.9	90	....
		No. of Samples	6	4	6	6	6	3	3	6	6	4	....
	10.5	Median	3.6	....	....	....	....	....	....	....	....	....	....
		Average	....	21	71	0	13	11.7	0.9	4	8.2	94	....
		Maximum	43	22	400	0.01	20	12.9	1.0	6	8.6	97	....
		Minimum	<3.0	18	0	0	10	11.0	0.8	2	7.9	88	....
		No. of Samples	6	4	6	6	6	3	3	6	6	4	....

220 p.p.b. was noted. A similar reduction in values was found offshore.

The main body of water at the eastern end of Lake Erie is of good sanitary quality and is relatively free from domestic and industrial pollution. Median coliform M.P.N. values were less than 10 per 100 ml. Phenol concentrations averaged about 1 p.p.b. with maximums up to 6 p.p.b., except for one sample taken in the vicinity of Seneca Shoal which contained 140 p.p.b. and for which no reason is apparent. Turbidity averages ranged from 1 to 4 p.p.m. with a maximum value only slightly higher.

The water along the Canadian shore was also of good sanitary quality, with median coliform M.P.N. values ranging from less than 3 to 16 per 100 ml. Phenol results averaged about 1 p.p.b. except along the range LC offshore from Crystal Beach, where the averages were considerably higher. A maximum as high as 400 p.p.b. was noted on this range and again there is no satisfactory explanation.

Upper Niagara River

The analytical results for the upper Niagara River are summarized in table N-18 (see pages 271 to 279). The more significant analyses, coliform M.P.N. median and maximum values are shown in figure N-5, and phenol averages and maximums in figure N-6.

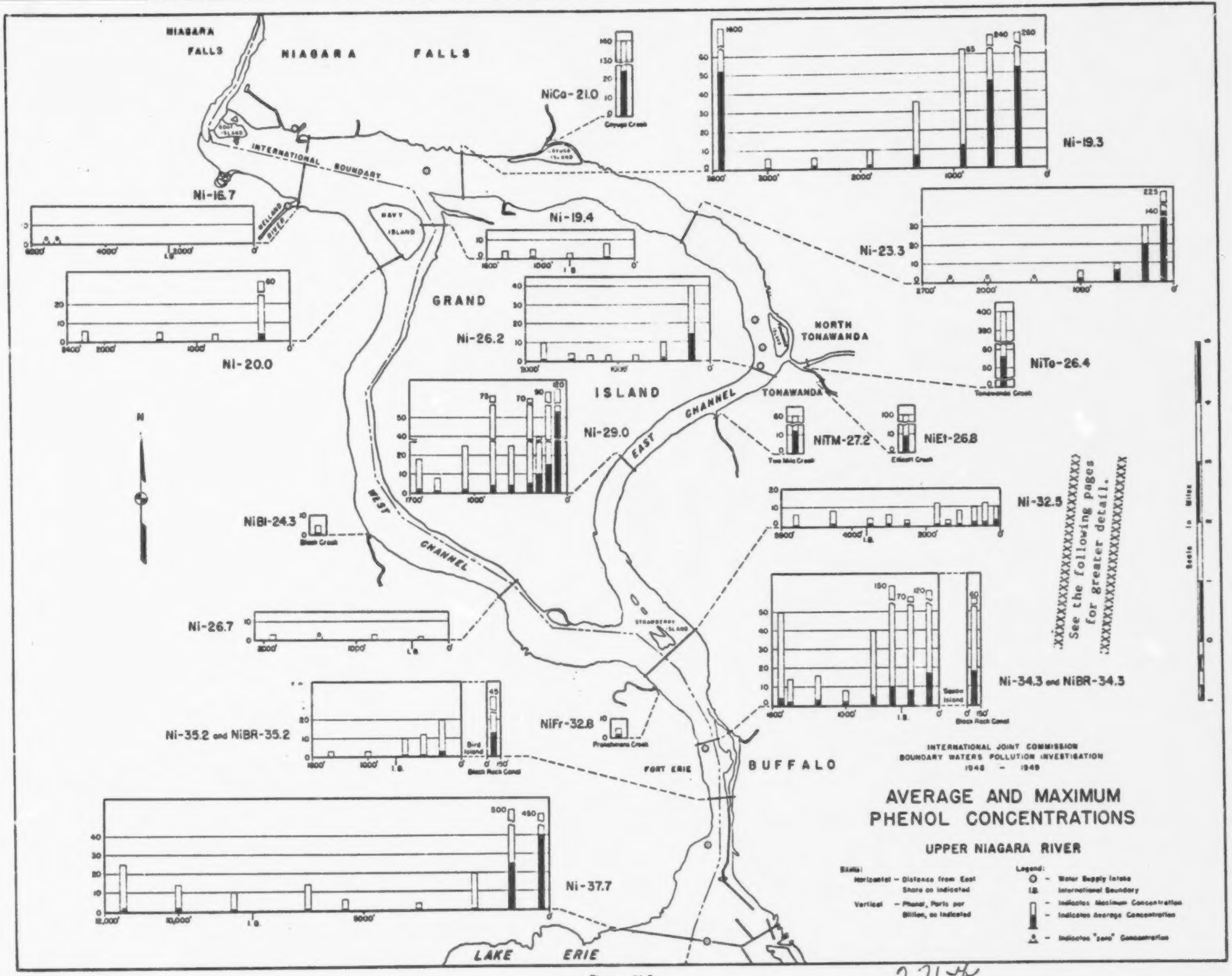
The high velocity of flow in the upper Niagara River, mentioned in chapter N-IV, causes marked stratification within the river paralleling the shore. As a result, the unpolluted waters from the main body of Lake Erie remain separated under normal meteorological conditions from the flow in the easterly portion of the river. This easterly section is subject to pollution from the Buffalo River and harbor area, sewer outlets, and sewage treatment plant outfalls along the United States shore. The analyses of samples taken on ranges extending across the width of the river from its inlet to Grand Island and in the East and West Channels definitely revealed the pollution zone paralleling the shore. Furthermore, this pollution zone along the easterly portion of the river is marked by visible color and turbidity, part of which is due to surface run-off from tributaries.

This stratification of pollution, however, is influenced by meteorological conditions. For instance, strong southwesterly winds or seiches in Lake Erie may create an undertow which would tend to spread the pollution zone westerly by bringing pollution from the Buffalo River and the harbor area farther into the lake, and consequently, farther west from the United States shore in the Niagara River. Also, winds, ice jams, and heavy tributary run-offs along the river may modify the hydraulics and affect the limits of this zone of pollution. The river samples were taken under a variety of meteorological conditions during all seasons of the year. The summary of analytical results, therefore, represents the average of varying conditions of the river. It should be noted, however, that the river during the winter of 1948-49 was relatively free of ice, and that sampling during severe winds was not always possible.

The water entering the Niagara River is highly polluted along the United States shore, but is of good sanitary quality, similar to the main body of Lake Erie, on the westerly side. Above the river inlet the pollution originating from the Buffalo River and harbor area is mostly confined to the outer harbor which is bordered on the west by breakwaters paralleling the shore some 3,000 feet distant. Within the zone of pollution at the northern outlet of the outer harbor, the median coliform M.P.N. values were 7,500 per 100 ml. near the shore, decreasing to 59 per 100 ml. near the breakwater; the maximum was 110,000. Phenols, likewise, decreased from an average of 40 p.p.b. near the shore to 1 p.p.b. near the breakwater. The maximum phenol results ranged from 500 to 20 p.p.b.

That this pollution is due in part to the Buffalo River is indicated by the high median coliform M.P.N. of 9,300 per 100 ml., with a maximum of 240,000, and a high phenol average of 469 p.p.b. with a maximum of 1,400, found a short distance upstream from the mouth of the river. Similar high coliform values prevailed upstream beyond the Cazenovia Creek confluence with the Buffalo River. Phenols, however, were considerably reduced upstream with an average of about 40 p.p.b. at the Cazenovia Creek confluence. It should be noted that the sampling schedule for the Buffalo River permitted sampling only during the winter and spring months. While the concentrations of pollutants during the low river flows in the summer months are not shown, their effects were measured on the Niagara River ranges.

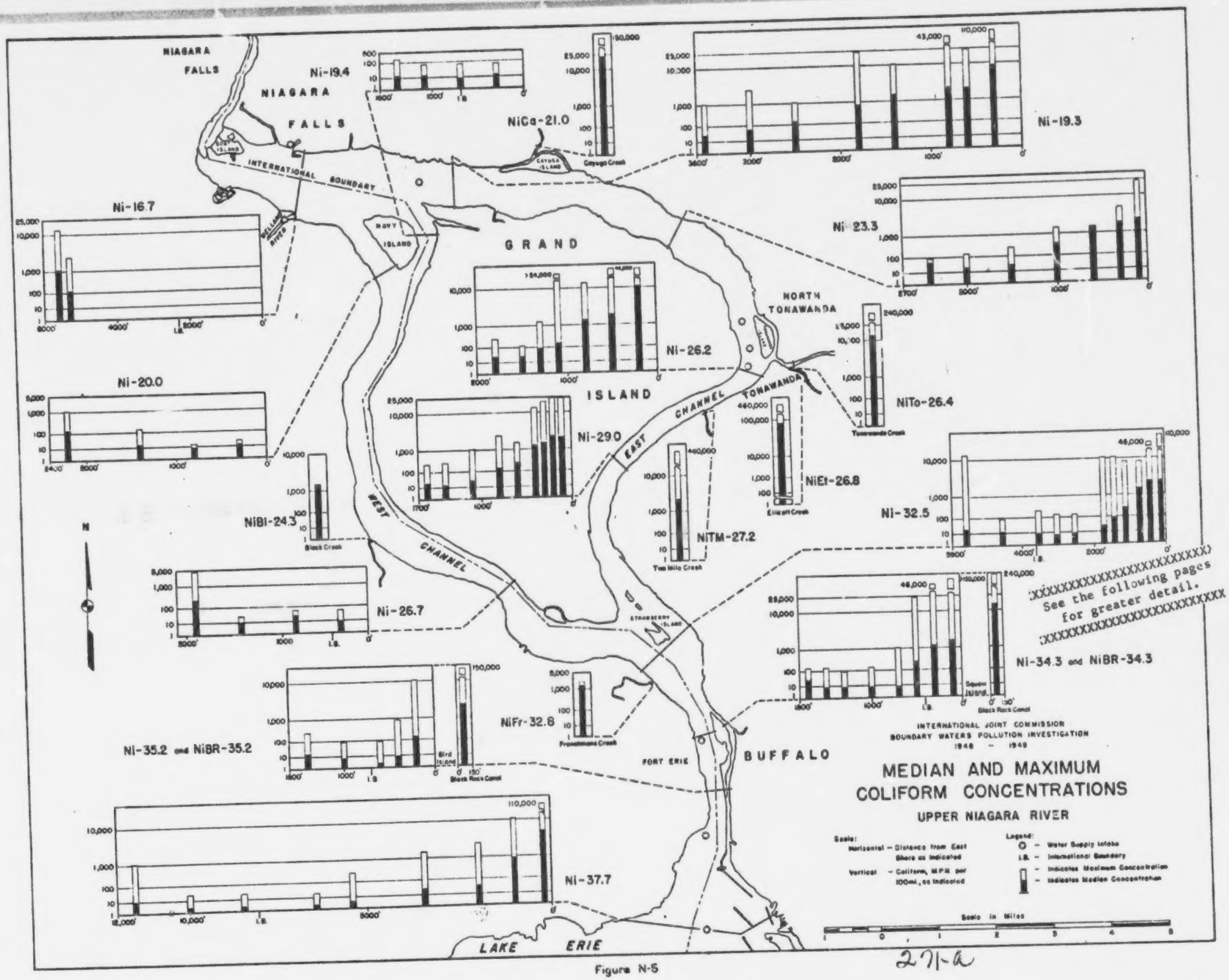
From the Niagara River inlet to a sampling range across the river at Strawberry Island (Ni - 32.5), the pollution zone is confined to the easterly portion of the river, gradually expanding westward during this course of flow downstream. The Black Rock Canal receives the heaviest concentration of pollutants since its location serves as a natural outlet from the Buffalo River and as a receiving stream for shore drainage and storm water overflows. The flow of sewage pollution into the canal is indicated by the median coliform M.P.N. of 15,000 per 100 ml., with a maximum of 240,000, found near the canal outlet. A large amount of the pollution follows the river on the west side of the canal breakwater, even though the concentration is not as great as in the canal. The pollution zone, based on the coliform results, extends about 500 feet from the shore of Bird Island on the United States side


INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 - 1949
AVERAGE AND MAXIMUM PHENOL CONCENTRATIONS
UPPER NIAGARA RIVER
Scale:
Horizontal - Distance from East Shore as indicated
Vertical - Phenol, Parts per Billion, as indicated
Legend:
○ - Water Supply Intake
I.B. International Boundary
- Indicates Maximum Concentration
- Indicates Average Concentration
- Indicates "zero" Concentration
Scale in Miles
NIAGARA FALLS
NIAGARA FALLS
GOAT ISLAND
INTERNATIONAL BOUNDARY
WELLAND RIVER
NAVY ISLAND
CAYUGA ISLAND
GRAND ISLAND
NORTH TONAWANDA
TONAWANDA
EAST CHANNEL
WEST CHANNEL
STRAWBERRY ISLAND
FORT ERIE
BUFFALO
LAKE ERIE
Ni-16.7
Ni-19.3
Ni-19.4
NiCa-21.0
Cayuga Creek
Ni-20.0
Ni-23.3
Ni-26.2
NiTo-26.4
Tonawanda Creek
Ni-29.0
NiTM-27.2
Two Mile Creek
NiEl-26.8
Ellicott Creek
NiBl-24.3
Black Creek
Ni-32.5
Ni-26.7
Ni-34.3 and NiBR-34.3
Squaw Island
Black Rock Canal
NiFr-32.8
Frenchmans Creek
Ni-35.2 and NiBR-35.2
Bird Island
Ni-37.7
N

XXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXX

Figure N-6

271-f


NIAGARA FALLS
NIAGARA FALLS
INTERNATIONAL BOUNDARY
NAVY ISLAND
GRAND ISLAND
NORTH TONAWANDA
TONAWANDA
EAST CHANNEL
WEST CHANNEL
STRAWBERRY ISLAND
FORT ERIE
BUFFALO
LAKE ERIE
Ni-16.7
Ni-19.4
NiCa-21.0
Cayuga Creek
Ni-19.3
Ni-23.3
Ni-20.0
Ni-26.2
Ni-29.0
NiBl-24.3
Black Creek
NiTo-26.4
Tonawanda Creek
NiEl-26.8
Ellicott Creek
NiTM-27.2
Two Mile Creek
Ni-32.5
Ni-26.7
NiFr-32.8
Frenchmans Creek
Ni-34.3 and NiBR-34.3
Squaw Island
Black Rock Canal
Ni-35.2 and NiBR-35.2
Bird Island
Ni-37.7
I.B.
N

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1949

MEDIAN AND MAXIMUM
COLIFORM CONCENTRATIONS
UPPER NIAGARA RIVER

Scale:
Horizontal - Distance from East Shore as Indicated
Vertical - Coliform, MPN per 100ml., as Indicated

Legend:
○ - Water Supply Intake
I.B. - International Boundary
▯ - Indicates Maximum Concentration
▮ - Indicates Median Concentration

Scale in Miles

XXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXX

Figure N-5

TABLE N-18—SUMMARY OF AVERAGE ANALYTICAL RESULTS—UPPER NIAGARA RIVER

Sampling Range and Mileage Index	Distance from East Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 Day ppm	Turbidity ppm	pH	Alkalinity ppm
NiBu-38.7. Buffalo River at Michigan Avenue Bridge, Buffalo, N. Y.	....	Median	9,300									
		Average		46	469	0.71	8	7.3	14.4	52	6.9	66
		Maximum	240,000	181	1,400	1.50	13	13.2	31.5	193	7.4	95
		Minimum	910	8	35	0.26	0	0	6.2	18	5.9	36
		No. of Samples	36	23	25	25	25	25	25	25	24	23
	0			United States Shore								
Ni-37.7. A range across the river just below the confluence of the Buffalo and Niagara Rivers and Buffalo Harbor and in line with the City of Buffalo water intake	200	Median	7,500									
		Average		26	40	0.18	14	8.6	2.6	15	7.7	90
		Maximum	110,000	34	450	0.92	27	11.5	20.0	64	8.2	96
		Minimum	460	19	0	0.01	4	4.7	0.5	3	6.7	81
		No. of Samples	40	20	40	32	41	41	39	41	41	20
	1,000	Median	930									
		Average		21	25	0.09	12	10.3	1.4	12	8.0	92
		Maximum	>11,000	27	500	0.60	26	13.0	11.3	61	8.5	96
		Minimum	21	18	0	0	3	6.6	0.4	2	7.1	82
		No. of Samples	33	10	33	28	31	31	29	31	31	10
	2,000	Median	59									
		Average		21	1	0.01	12	10.9	0.9	8	8.1	92
		Maximum	4,600	26	20	0.08	26	13.6	2.9	15	8.4	95
		Minimum	<3.0	18	0	0	3	7.9	0.2	1	7.5	86
		No. of Samples	38	11	39	28	33	33	31	33	33	11
	3,500	Median	43									
		Average		20	1	0	11	11.1	0.8	8	8.0	93
		Maximum	2,400	24	4	0.04	25	13.7	4.3	22	8.5	95
		Minimum	<3.0	18	0	0	3	8.2	0.2	1	7.4	84
		No. of Samples	33	8	34	27	30	27	27	30	30	7
	5,500	Median	6.3									
		Average		20	1	0	13	11.3	0.9	5	8.1	92
		Maximum	460	22	6	0.01	25	13.7	2.3	21	8.4	94
		Minimum	<3.0	18	0	0	3	8.3	0.4	1	7.7	84
		No. of Samples	25	8	25	20	24	12	12	24	24	8
	6,500			Water Intake—City of Buffalo, N. Y.								
	6,500	Median	3.6									
		Average		21	1	0	14	10.5	0.7	4	8.1	92
		Maximum	36	25	14	0.01	25	13.6	1.7	11	8.4	100
		Minimum	<3.0	17	0	0	3	7.5	0	1	7.4	84
		No. of Samples	31	15	31	24	31	19	17	31	30	15
	8,000			International Boundary								
	8,500	Median	3.6									
		Average		20	1	0	13	11.5	0.7	4	8.1	92
		Minimum	43	24	10	0.01	24	13.6	1.5	12	8.4	96
		Minimum	<3.0	17	0	0	3	8.4	0.3	1	7.4	84
		No. of Samples	31	8	31	21	24	12	11	24	24	8
	10,000	Median	3.6									
		Average		20	2	0	12	11.5	0.8	5	8.1	93
		Maximum	43	22	14	0.01	24	13.7	2.6	13	8.4	96
		Minimum	<3.0	18	0	0	3	8.2	0.3	1	7.5	86
		No. of Samples	24	7	24	20	23	11	11	23	23	7
	11,500	Median	9.1									
		Average		21	2	0	14	10.5	0.7	5	8.1	91
		Maximum	1,100	24	25	0.01	25	13.7	1.8	16	8.4	95
		Minimum	<3.0	18	0	0	3	7.3	0.1	1	7.6	88
		No. of Samples	31	15	31	24	31	19	18	31	31	15
	12,000			Canadian Shore								

TABLE N-18—SUMMARY OF AVERAGE ANALYTICAL RESULTS—UPPER NIAGARA RIVER—Continued

Sampling Range and Mileage Index	Distance from East Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_3 ppm	Temp. °C	D.O. ppm	B.O.D. 5 Day ppm	Turbidity ppm	pH	Alkalinity ppm
	0			West Shore of Bird Island								
Ni-35.2. A range across the river from the ferry dock on Bird Island to the Canadian shore	200	Median	150									
		Average		22	3	0.03	17	9.2	1.2	7	8.0	92
		Maximum	11,000	27	20	0.18	25.5	12.1	3.0	26	8.4	94
		Minimum	<3.0	17	0	0	4	8.0	0.1	1	7.7	88
		No. of Samples	21	15	21	14	21	14	14	21	20	15
	400	Median	9.1									
		Average		20	1	0	16	9.7	0.9	5	8.1	93
		Maximum	930	24	12	0.02	25	12.1	1.4	20	8.4	96
		Minimum	<3.0	17	0	0	4	8.5	0.3	1	7.7	88
		No. of Samples	21	9	21	11	15	8	8	15	15	9
	600	Median	3.6									
		Average		21	1	0	16	9.5	0.8	6	8.1	92
		Maximum	93	24	10	0.03	24.5	12.1	1.6	64	8.5	94
		Minimum	<3.0	16	0	0	4	8.3	0.2	1	7.7	88
		No. of Samples	21	13	21	14	19	12	12	19	18	13
	700			International Boundary								
	1,000	Median	8.1									
		Average		20	0	0	16	9.5	0.9	5	8.1	93
		Maximum	93	22	3	0	25	12.3	1.9	17	8.5	97
		Minimum	<3.0	17	0	0	4	8.5	0.1	1	7.7	88
		No. of Samples	20	9	20	11	15	7	7	15	15	9
	1,400	Median	23									
		Average		21	0	0	16	9.1	0.8	4	8.1	92
		Maximum	460	25	3	0.02	24	10.4	1.7	19	8.4	96
		Minimum	<3.0	18	0	0	4	8.4	0.2	1	7.7	86
		No. of Samples	21	15	21	14	21	12	12	21	21	15
	1,600			Canadian Shore								
NiBR-35.2. Black Rock Canal at Ferry Street Bridge, Buffalo, N. Y.		Median	4,300									
		Average		23	13	0.29	6	10.2	2.2	18	7.6	93
		Maximum	150,000	32	45	1.20	16	13.2	6.4	31	7.9	121
		Minimum	910	19	Trace	0.01	0	5.6	0.9	5	7.3	84
		No. of Samples	24	10	17	17	17	16	16	17	16	10
	0			West Shore of Squaw Island								
Ni-34.3. A range across the river at the International R. R. Bridge below the Buffalo Sewer Authority treatment plant	100	Median	2,400									
		Average		25	17	0.08	10	10.7	1.5	13.6	7.8	92
		Maximum	>150,000	42	120	0.24	26	14.6	3.5	45	8.3	100
		Minimum	43	17	0	0.01	0	7.0	0.4	2.0	7.2	86
		No. of Samples	44	14	35	26	37	36	35	37	36	14
	300	Median	1,500									
		Average		22	8	0.08	8	11.7	1.6	14	7.8	92
		Maximum	46,000	24	70	0.20	24	14.8	3.2	41	8.3	96
		Minimum	30	19	0	0	0	7.8	0.3	1	7.5	88
		No. of Samples	44	6	35	25	29	29	27	29	29	6
	400			International Boundary								
	500	Median	430									
		Average		22	10	0.03	7	12.0	0.9	13	7.9	95
		Maximum	24,000	29	150	0.12	24	14.7	2.4	35	8.4	98
		Minimum	9.1	17	0	0	0	8.0	0.3	1	7.5	92
		No. of Samples	35	5	26	24	28	28	28	28	28	5
	700	Median	9.1									
		Average		21	4	0.01	10	11.5	0.7	10	7.9	92
		Maximum	>1,100	31	40	0.10	24.5	14.6	2.0	32	8.4	96
		Minimum	<3.0	16	0	0	0	8.3	0.3	1	7.5	88
		No. of Samples	45	14	36	27	37	34	36	37	36	14

TABLE N-18—SUMMARY OF AVERAGE ANALYTICAL RESULTS—UPPER NIAGARA RIVER—Continued

Sampling Range and Mileage Index	Distance from East Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N ppm	Temp. °C	D.O. ppm	B.O.D. 5 Day ppm	Turbidity ppm	pH	Alkalinity ppm
Ni-34.3. (Continued)	1,000	Median	9.1									
		Average		21	2	0	8	11.9	0.7	12	7.9	93
		Maximum	240	24	8	0.01	24	14.5	1.7	32	8.4	96
		Minimum	<3.0	18	0	0	0	8.2	0.2	1	7.5	88
		No. of Samples	34	5	26	23	24	18	22	27	27	5
	1,300	Median	9.1									
		Average		21	3	0	8	12.1	0.6	12	7.9	94
		Maximum	93	26	16	0.01	24	14.4	1.7	26	8.5	96
		Minimum	<3.0	18	0	0	0	8.3	0	1	7.4	92
		No. of Samples	34	5	25	23	27	17	21	27	27	5
	1,600	Median	9.1									
		Average		21	2	0	8	12.0	0.6	12	7.9	92
		Maximum	240	24	14	0.02	24	14.4	1.5	35	8.5	96
		Minimum	<3.0	17	0	0	0	8.3	0.2	1	7.5	86
		No. of Samples	44	6	34	24	28	18	22	28	28	6
	1,700	Median	23									
		Average		21	4	0	10	11.3	0.8	11	7.9	92
		Maximum	210	23	50	Trace	24	14.4	2.8	50	8.3	98
		Minimum	<3.6	18	0	0	0	8.4	0.2	1	7.5	88
		No. of Samples	45	14	36	27	38	26	31	37	36	14
	1,800			Canadian Shore								
NiBR-34.3. Black Rock Canal at International Bridge, Buffalo, N. Y.		Median	15,000									
		Average		23	18	0.36	6	8.6	3.1	19	7.4	96
		Maximum	240,000	28	60	1.60	16	12.4	10.2	53	7.8	105
		Minimum	910	19	Trace	0.08	0	4.8	0.9	6	7.2	89
		No. of Samples	27	10	19	20	20	20	19	20	19	10
NiFr-32.8. Frenchmans Creek at confluence with Upper Niagara River		Median	1,470									
		Average		16	2	0.08	4	9.9	2.6	55	7.5	78
		Maximum	2,400	27	5	0.08	6	12.2	3.7	110	8.1	122
		Minimum	540	5	0	0.08	1	7.2	2.0	15	7.2	32
		No. of Samples	4	4	4	1	3	4	4	4	4	4
	0			United States Shore								
Ni-32.5. A range across the river at the head of Strawberry Island	100	Median	4,450									
		Average		23	3	0.03	18	9.1	1.6	9	8.0	92
		Maximum	110,000	26	10	0.08	26	11.8	4.6	48	8.4	96
		Minimum	430	17	0	0	4	7.6	0.4	1	7.6	86
		No. of Samples	22	14	22	14	22	21	21	22	22	13
	400	Median	4,300									
		Average		23	2	0.04	18	9.2	1.5	8	8.1	92
		Maximum	46,000	28	12	0.10	25	11.7	4.5	43	8.4	96
		Minimum	91	18	0	0	4	7.8	0.5	1	7.6	86
		No. of Samples	23	14	23	14	22	21	21	22	22	13
	700	Median	2,300									
		Average		21	2	0.04	17	9.4	1.1	6	8.1	93
		Maximum	9,300	24	10	0.10	25	11.7	2.2	30	8.5	96
		Minimum	<3.0	18	0	0	4	8.2	0.2	1	7.6	88
		No. of Samples	19	11	19	11	19	19	18	19	19	10
	1,100	Median	230									
		Average		21	1	0.02	17	9.5	0.8	6	8.1	92
		Maximum	9,300	26	8	0.06	25	11.9	2.4	32	8.5	96
		Minimum	3.6	17	0	0	4	8.4	0.2	1	7.5	88
		No. of Samples	21	12	21	13	20	19	18	20	20	11
	1,400	Median	93									
		Average		20	1	0.01	17	9.2	0.7	5	8.2	93
		Maximum	11,000	25	3	0.08	25	11.0	1.[illegible]	26	8.5	96
		Minimum	<3.0	18	0	0	4	8.2	0.1	1	7.6	86
		No. of Samples	19	11	18	11	19	12	12	19	19	10

TABLE N-18—SUMMARY OF AVERAGE ANALYTICAL RESULTS—UPPER NIAGARA RIVER—Continued

Sampling Range and Mileage Index	Distance from East Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 Day ppm	Turbidity ppm	pH	Alkalinity ppm
Ni-32.5 (Continued)	1,700	Median	23									
		Average		22	1	0.01	17	9.1	0.7	4	8.1	92
		Maximum	11,000	27	12	0.06	25	11.0	1.2	21	8.5	96
		Minimum	3.0	18	0	0	4	8.3	0	1	7.5	86
		No. of Samples	22	14	22	14	22	14	13	22	22	13
	2,500	Median	9.1									
		Average		21	1	0	17	9.1	1.0	3	8.1	92
		Maximum	240	26	3	Trace	25	11.1	3.9	14	8.6	95
		Minimum	<3.0	18	0	0	4	8.4	0	1	7.5	88
		No. of Samples	23	14	22	13	21	12	12	21	21	13
	3,000	Median	8.2									
		Average		21	1	0	17	9.1	0.7	4	8.2	93
		Maximum	240	26	6	Trace	25	11.2	1.5	19	8.6	97
		Minimum	<3.0	18	0	0	4	8.3	0.2	1	7.5	88
		No. of Samples	22	13	22	13	21	13	12	21	21	12
	3,500	Median	9.1									
		Average		21	1	0	17	9.2	0.6	4	8.2	93
		Maximum	360	27	4	Trace	25.5	11.3	1.0	17	8.5	97
		Minimum	<3.0	17	0	0	4	8.4	0.2	1	7.6	88
		No. of Samples	23	13	23	13	21	12	12	20	20	12
	3,600			International Boundary								
	4,500	Median	14.5									
		Average		21	1	0	17	9.1	0.9	4	8.1	93
		Maximum	93	25	8	Trace	26	11.4	1.9	24	8.5	98
		Minimum	<3.0	17	0	0	4	7.5	0.1	1	7.5	88
		No. of Samples	22	14	22	14	22	14	13	22	22	13
	5,500	Median	30									
		Average		22	0	0	17	9.1	1.5	4	8.2	93
		Maximum	15,000	26	6	0.01	26	11.2	3.0	21	8.5	96
		Minimum	<3.0	18	0	0	4	6.9	0.3	1	7.6	90
		No. of Samples	22	13	22	13	21	12	12	21	21	12
	5,900			Canadian Shore								
	0			United States Shore								
Ni-29.0. A range across the East Channel at the South Grand Island Bridge	100	Median	3,900									
		Average		21	53	0.11	7	11.8	1.5	14	7.7	92
		Maximum	24,000	22	120	0.26	24	14.2	2.2	35	8.3	96
		Minimum	230	19	0	0	0	7.7	0.7	2	7.1	88
		No. of Samples	29	7	20	16	20	18	19	20	20	7
	200	Median	4,300									
		Average		22	15	0.07	11	10.9	1.4	11	7.8	92
		Maximum	24,000	26	90	0.24	24	14.4	2.5	35	8.3	96
		Minimum	430	18	0	0	0	7.2	0.6	1	7.3	90
		No. of Samples	35	14	27	22	27	24	25	27	25	14
	300	Median	2,300									
		Average		19	10	0.06	7	12.4	1.0	14	7.8	94
		Maximum	21,000	21	40	0.18	24	14.4	2.2	34	8.4	95
		Minimum	91	18	0	0	0	7.8	0.3	1	7.4	92
		No. of Samples	26	5	18	16	18	16	16	18	18	5
	400	Median	1,900									
		Average		19	5	0.03	8	12.0	0.9	14	7.8	93
		Maximum	15,000	21	70	0.06	24	14.6	1.7	35	8.4	96
		Minimum	43	18	0	0	0	8.0	0.3	1	7.4	90
		No. of Samples	34	7	26	15	19	17	18	19	19	7
	600	Median	430									
		Average		19	4	0.02	7	12.8	0.8	15	7.8	93
		Maximum	2,400	22	25	0.06	24	14.5	1.6	34	8.5	96
		Minimum	23	18	0	0	0	8.3	0.3	1	7.5	92
		No. of Samples	26	5	18	16	18	14	15	18	18	5

Table N-18—Summary of Average Analytical Results—Upper Niagara River—Continued

Sampling Range and Mileage Index	Distance from East Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 Day ppm	Turbidity ppm	pH	Alkalinity ppm
Ni-29.0. (Continued)	800	Median	230									
		Average		21	4	0.01	11	11.1	0.8	11	7.9	92
		Maximum	4,600	25	75	0.08	24	14.5	3.6	34	8.5	96
		Minimum	7.3	17	0	0	0	8.0	0.2	1	7.5	88
		No. of Samples	35	13	27	22	27	18	22	26	25	14
	1,100	Median	43									
		Average		19	2	0.01	7	13.5	0.6	14	7.8	94
		Maximum	1,100	22	25	0.04	23	14.5	1.5	30	8.5	95
		Minimum	<3.0	18	0	0	0	8.0	0.1	1	7.5	92
		No. of Samples	35	5	27	16	18	10	13	18	18	5
	1,400	Median	23									
		Average		22	1	0	10	11.4	0.8	9	7.9	92
		Maximum	460	26	8	0.02	24	14.5	2.4	29	8.4	96
		Minimum	<3.0	18	0	0	0	8.0	0.2	1	7.5	88
		No. of Samples	33	13	26	21	26	20	22	26	24	13
	1,600	Median	31									
		Average		19	2	0.01	7	13.5	0.5	13	7.8	95
		Maximum	430	20	18	0.06	23	14.7	0.8	25	8.5	96
		Minimum	<3.0	18	0	0	0	8.7	0.1	1	7.5	92
		No. of Samples	26	5	18	17	18	11	13	18	18	5
	1,700			East Shore of Grand Island								
NiTo-26.4. Tonawanda Creek at Delaware Ave. Bridge, Tonawanda, N. Y.		Median	15,000									
		Average		20	56	0.19	8	9.9	3.9	17	7.6	100
		Maximum	240,000	30	400	0.44	25	13.7	9.9	36	8.3	126
		Minimum	2,300	9	0	0	0	4	1.3	6	7.3	79
		No. of Samples	40	32	32	32	32	32	31	32	31	32
	0			United States Shore								
Ni-26.2. A range across the East Channel near the City of Tonawanda water intake	200	Median	10,150									
		Average		22	14	0.03	16	8.9	1.1	8	7.9	93
		Maximum	46,000	30	40	0.10	24	12.0	2.3	35	8.3	96
		Minimum	430	18	0	0	2	7.3	0.3	1	7.5	88
		No. of Samples	20	15	20	15	20	18	19	20	18	15
	500	Median	3,500									
		Average		19	2	0.02	13	9.8	1.0	10	8.0	94
		Maximum	46,000	22	10	0.06	24	12.1	1.7	32	8.4	95
		Minimum	110	17	0	0	3	7.5	0.4	1	7.6	92
		No. of Samples	20	6	20	8	11	9	10	11	11	6
	800	Median	2,100									
		Average		19	0	0.01	13	9.9	0.8	10	8.0	95
		Maximum	15,000	20	3	0.04	24	12.2	1.8	29	8.4	96
		Minimum	36	16	0	0	2	7.1	0.1	1	7.5	94
		No. of Samples	11	6	11	9	11	9	10	11	11	6
	1,100	Median	250									
		Average		21	0	0	16	9.4	0.8	6	8.0	93
		Maximum	>24,000	24	3	0.01	24	12.1	2.1	27	8.5	96
		Minimum	9.1	17	0	0	3	7.8	0.1	1	7.3	88
		No. of Samples	20	15	20	15	20	17	18	20	18	15
	1,300	Median	93									
		Average		20	0	0.01	13	8.5	0.4	7	8.0	95
		Maximum	>1,500	21	3	0.04	24	8.8	0.7	21	8.5	96
		Minimum	9.1	19	0	0	3	8.0	0.2	1	7.7	94
		No. of Samples	19	5	19	8	10	4	5	10	10	5
	1,500			Water Intake—City of Tonawanda, N. Y.								
	1,500	Median	43									
		Average		19	1	0	13	8.5	0.3	8	8.0	95
		Maximum	150	21	4	0	24	8.7	0.5	21	8.5	96
		Minimum	<3.6	17	0	0	3	8.0	0.2	1	7.4	94
		No. of Samples	11	6	11	9	11	4	5	11	11	6

TABLE N-18—SUMMARY OF AVERAGE ANALYTICAL RESULTS—UPPER NIAGARA RIVER—Continued

Sampling Range and Mileage Index	Distance from East Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 Day ppm	Turbidity ppm	pH	Alkalinity ppm
Ni-26.2. (Continued)	1,800	Median	43	....	....	....	....	....	....	....	....	....
		Average	....	21	1	0	16	8.6	0.7	5	8.0	92
		Maximum	460	24	10	0.06	24	10.1	1.4	18	8.5	96
		Minimum	<3.0	17	0	0	3	8.0	0.2	1	7.5	90
		No. of Samples	20	15	20	15	20	13	14	20	18	15
	2,000			East Shore of Grand Island								
NiEt-26.8. Ellicott Creek at Fremont St. Bridge, City of Tonawanda, N. Y.		Median	93,000	....	....	....	....	....	....	....	....	....
		Average	....	22	9	0.76	8	8.1	4.3	15	7.5	126
		Maximum	460,000	44	100	2.8	25	12.6	10.5	34	8.2	171
		Minimum	2,300	9	0	0.16	0	0.9	1.6	4	7.1	93
		No. of Samples	41	33	33	32	33	32	32	32	32	33
NiTM-27.2. Two Mile Creek at River Road Bridge, 0.5 mile south of City of Tonawanda N. Y.		Median	4,300	....	....	....	....	....	....	....	....	....
		Average	....	61	12	0.35	5	8.4	7.0	21	7.6	142
		Maximum	460,000	190	60	0.90	17	11.9	17.3	46	8.7	209
		Minimum	360	16	0	0.03	0	0.6	1.9	6	7.3	80
		No. of Samples	36	28	28	27	28	27	27	28	27	28
	0			United States Shore								
Ni-23.3. A range across the East Channel below the City of North Tonawanda, on a line between buoy ranges 11 and 12	100	Median	4,300	....	....	....	....	....	....	....	....	....
		Average	....	23	140	0.14	4	10.8	2.3	17	7.6	94
		Maximum	24,000	24	225	0.18	5	11.4	2.9	27	7.6	96
		Minimum	4,300	21	66	0.12	2	10.3	1.6	8	7.5	92
		No. of Samples	4	2	4	4	4	3	3	4	4	2
	300	Median	3,300	....	....	....	....	....	....	....	....	....
		Average	....	21	20	0.08	4	11.2	1.8	16	7.7	95
		Maximum	7,500	21	30	0.12	5	11.6	2.1	37	7.8	95
		Minimum	930	20	10	0.06	2	11.0	1.6	6	7.5	95
		No. of Samples	4	2	4	4	4	3	3	4	4	2
	600	Median	1,900	....	....	....	....	....	....	....	....	....
		Average	....	21	6	0.04	4	11.5	1.1	14	7.7	97
		Maximum	2,300	22	10	0.06	5	11.7	1.7	24	7.9	97
		Minimum	1,500	19	Trace	0.01	2	11.3	0.8	6	7.5	96
		No. of Samples	4	2	4	4	4	3	3	4	4	2
	1,000	Median	590	....	....	....	....	....	....	....	....	....
		Average	....	20	2	0.04	4	11.5	0.9	13	7.7	96
		Maximum	2,300	20	6	0.06	5	11.8	1.3	24	7.9	96
		Minimum	230	19	0	0	2	11.3	0.6	5	7.5	96
		No. of Samples	4	2	4	4	4	3	3	4	4	2
	1,500	Median	43	....	....	....	....	....	....	....	....	....
		Average	....	19	Trace	0	4	....	....	12	7.7	97
		Maximum	430	19	Trace	0	5	....	....	22	7.8	97
		Minimum	39	19	0	0	2	....	....	6	7.5	96
		No. of Samples	4	2	4	4	4	....	....	4	4	2
	2,000	Median	32	....	....	....	....	....	....	....	....	....
		Average	....	20	0	0	4	....	....	10	7.7	96
		Maximum	230	20	Trace	0	5	....	....	19	7.8	97
		Minimum	21	19	0	0	2	....	....	4	7.5	95
		No. of Samples	4	2	4	4	4	....	....	4	4	2
	2,400	Median	68	....	....	....	....	....	....	....	....	....
		Average	....	20	Trace	0	4	....	....	11	7.7	96
		Maximum	93	20	Trace	0	5	....	....	19	7.9	96
		Minimum	9.1	19	0	0	2	....	....	5	7.5	95
		No. of Samples	4	2	4	4	4	....	....	4	4	2
	2,700			East Shore of Grand Island								
NiCa-21.0. Cayuga Creek at 88th Street Bridge, Niagara Falls, N. Y.		Median	23,000	....	....	....	....	....	....	....	....	....
		Average	....	22	24	0.27	9	8.0	3.9	22	7.6	111
		Maximum	150,000	33	140	0.72	25	13.1	8.9	86	8.1	155
		Minimum	4,300	8	0	0	0	3.8	2.1	4	7.3	57
		No. of Samples	35	27	27	26	27	25	26	27	27	27

TABLE N-18—SUMMARY OF AVERAGE ANALYTICAL RESULTS—UPPER NIAGARA RIVER—Continued

Sampling Range and Mileage Index	Distance from East Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_1 ppm	Temp. °C	D.O. ppm	B.O.D. 5 Day ppm	Turbidity ppm	pH	Alkalinity ppm
	0			United States Shore								
Ni-19.3. A range across the East Channel at the North Grand Island Bridge	300	Median	9,300									
		Average		25	53	0.08	11	10.1	1.8	12	7.8	91
		Maximum	110,000	28	260	0.24	24	13.9	3.9	36	8.3	94
		Minimum	430	20	0	0	0	6.0	0.3	1	7.3	82
		No. of Samples	43	14	32	27	32	31	32	32	30	13
	600	Median	3,900									
		Average		22	46	0.07	8	11.4	1.8	14	7.7	92
		Maximum	24,000	23	240	0.22	24	14.3	3.3	28	8.3	94
		Minimum	230	22	3	0	0	7.1	0.9	1	7.4	90
		No. of Samples	35	5	24	22	24	22	24	24	24	4
	900	Median	4,100									
		Average		21	12	0.04	8	11.7	1.4	12	7.9	92
		Maximum	43,000	23	65	0.12	24	14.5	2.8	28	8.3	94
		Minimum	230	20	0	0	0	7.6	0.2	1	7.3	88
		No. of Samples	44	5	33	22	24	22	24	24	24	4
	1,400	Median	2,300									
		Average		20	7	0.02	8	11.9	1.1	11	7.8	91
		Maximum	>11,000	22	35	0.06	24	14.4	2.8	21	8.4	94
		Minimum	23	19	0	0	0	8.1	0.5	1	7.3	84
		No. of Samples	35	5	24	22	24	20	22	24	24	4
	1,900	Median	930									
		Average		22	2	0.01	11	11.3	0.9	9	7.9	92
		Maximum	24,000	27	10	0.03	24	14.5	2.5	22	8.4	96
		Minimum	23	18	0	0	0	8.1	0	1	7.4	88
		No. of Samples	44	14	33	28	33	25	26	33	31	13
	2,500	Median	230									
		Average		20	2	0	8	13.1	0.6	10	7.9	96
		Maximum	>1,100	20	6	0.01	24	14.5	2.1	22	8.5	102
		Minimum	15	18	0	0	0	9.2	0.2	1	7.5	92
		No. of Samples	33	5	23	22	23	14	16	23	23	4
	3,000	Median	75									
		Average		21	1	0.01	8	13.3	0.6	10	7.9	95
		Maximum	4,600	24	6	0.06	24	14.5	1.3	19	8.5	98
		Minimum	3.6	18	0	0	0	9.1	0.1	1	7.5	92
		No. of Samples	42	5	32	21	23	15	16	23	23	4
	3,500	Median	43									
		Average		21	52	0	11	11.5	1.0	8	7.9	92
		Maximum	1,100	24	1,600	0.06	24	14.4	>7.2	25	8.5	104
		Minimum	9.1	17	0	0	0	7.9	0.1	1	7.5	88
		No. of Samples	43	14	32	25	32	24	24	32	30	13
	3,600			East Shore of Grand Island								
	0			West Shore of Grand Island								
Ni-26.7. A range across the West Channel below Beaver Island State Park	300	Median	9.1									
		Average		22	0	0	21	9.7	1.1	3	8.3	93
		Maximum	73	25	2	0	25	12.1	2.5	7	8.6	96
		Minimum	<3.0	18	0	0	12	8.6	0	1	7.9	90
		No. of Samples	18	11	17	8	13	8	8	13	13	10
	400			International Boundary								
	800	Median	23									
		Average		21	0	0	19	9.3	1.1	3	8.2	93
		Maximum	75	25	3	0	25	10.9	4.3	7	8.5	96
		Minimum	<3.0	17	0	0	12	8.5	0.1	1	7.9	88
		No. of Samples	17	14	18	7	16	12	12	15	16	13
	1,400	Median	10									
		Average		22	0	0	19	9.3	0.8	3	8.2	93
		Maximum	43	26	0	0.02	25	11.0	2.1	10	8.5	96
		Minimum	<3.0	18	0	0	12	8.2	0.3	1	7.9	88
		No. of Samples	18	14	18	8	16	12	12	15	16	13

TABLE N-18—SUMMARY OF AVERAGE ANALYTICAL RESULTS—UPPER NIAGARA RIVER—Continued

Sampling Range and Mileage Index	Distance from East Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 Day ppm	Turbidity ppm	pH	Alkalinity ppm
Ni-26.7 (Continued)	1,900	Median	445									
		Average		22	0	0	21	9.2	0.9	2	8.3	92
		Maximum	2,400	26	3	0	25	10.9	2.1	7	8.5	95
		Minimum	11	18	0	0	12	8.2	0.1	1	7.9	88
		No. of Samples	18	11	17	8	12	9	9	13	13	10
	2,100			Canadian Shore								
NiBl-24.3. Black Creek at confluence with West Channel, Willoughby Township, Ontario		Median	2,400									
		Average		18	1	0.36	4	10.7	2.1	74	7.5	61
		Maximum	2,400	45	5	0.36	6	11.9	3.3	150	7.9	96
		Minimum	1,700	5	0	0.36	1	9.0	1.1	38	7.2	26
		No. of Samples	4	4	4	1	3	4	4	4	4	4
	0			West Shore of Navy Island								
Ni-20.0. A range across the West Channel from the head of Navy Island to the Canadian Shore	300	Median	23									
		Average		22	4	0	18	9.6	0.8	2	8.2	92
		Maximum	43	25	60	0.01	25	12.0	1.3	5	8.4	94
		Minimum	<3.0	19	0	0	8	8.0	0.2	1	7.7	90
		No. of Samples	16	7	16	9	11	7	6	11	11	7
	800	Median	9.1									
		Average		21	0	0	17	9.7	0.9	4	8.2	92
		Maximum	23	25	4	Trace	25	11.6	1.3	15	8.4	96
		Minimum	<3.0	18	0	0	8	8.1	0.5	1	7.7	90
		No. of Samples	16	10	16	8	14	10	9	13	14	10
	1,400	Median	23									
		Average		21	1	0	17	9.8	0.6	4	8.1	93
		Maximum	150	25	5	0	25	11.7	1.1	12	8.4	98
		Minimum	<3.0	19	0	0	8	8.0	0.3	1	7.7	90
		No. of Samples	16	9	16	8	13	9	8	13	13	9
	2,200	Median	190									
		Average		22	0	0	18	9.5	0.8	3	8.2	92
		Maximum	1,100	24	6	Trace	25	11.7	1.6	9	8.4	95
		Minimum	21	18	0	0	8	7.8	0.5	1	7.7	88
		No. of Samples	16	7	15	9	11	7	6	11	11	7
	2,400			Canadian Shore								
	0			West Shore of Grand Island								
Ni-19.4. A range across the International Branch of the West Channel between Grand Island and Navy Island	300	Median	23									
		Average		22	1	0	18	9.6	1.8	3	8.2	92
		Maximum	93	24	8	Trace	25	11.6	5.2	7	8.4	94
		Minimum	<3.0	19	0	0	8	8.0	0.3	1	7.5	90
		No. of Samples	18	7	17	10	12	7	7	12	12	7
	700			International Boundary								
	700	Median	9.1									
		Average		22	0	0	17	9.8	0.9	3	8.2	90
		Maximum	93	26	3	0	25	11.6	2.7	10	8.4	96
		Minimum	<3.0	18	0	0	8	8.0	0.3	1	7.7	68
		No. of Samples	18	9	17	9	14	9	9	14	14	9
	1,100	Median	23									
		Average		22	1	0	17	9.6	1.1	3	8.1	91
		Maximum	93	27	5	Trace	25	11.6	2.3	10	8.4	96
		Minimum	<3.0	19	0	0	8	8.1	0.2	1	7.6	81
		No. of Samples	18	10	17	9	15	10	10	14	15	10
	1,400	Median	19									
		Average		22	0	0	18	9.7	0.8	3	8.2	92
		Maximum	230	24	4	Trace	25	11.7	1.4	7	8.6	95
		Minimum	<3.0	19	0	0	8	8.3	0.4	1	7.5	88
		No. of Samples	18	7	16	10	12	6	7	12	12	7

TABLE N-18—SUMMARY OF AVERAGE ANALYTICAL RESULTS—UPPER NIAGARA RIVER—Continued

Sampling Range and Mileage Index	Distance from East Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 Day ppm	Turbidity ppm	pH	Alkalinity ppm
Ni-19.4. (Continued)	1,600			East Shore of Navy Island								
	0			United States Shore								
	2,300			International Boundary								
Ni-16.7. A range across the upper Niagara River from a point upstream from Grass Island to the mouth of the Welland River	5,300	Median	120	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Outside	Average	.....	.....	0	.....	.....	.....	.....	.....	.....	.....
	Mouth	Maximum	4,600	.....	0	.....	.....	.....	.....	.....	.....	.....
		Minimum	3.6	.....	0	.....	.....	.....	.....	.....	.....	.....
		No. of Samples	4	.....	4	.....	.....	.....	.....	.....	.....	.....
	5,600	Median	1,100	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Inside	Average	.....	19	0	0.48	12	10.9	0.9	17	7.9	90
	Mouth	Maximum	>15,000	23	Trace	0.48	12	11.4	2.8	25	8.0	94
		Minimum	460	17	0	0.48	11	10.5	0	8	7.6	88
		No. of Samples	5	5	4	1	2	5	5	5	5	5
	6,000			Canadian Shore								
UPPER NIAGARA RIVER TRIBUTARIES												
NiBu-37.8. Buffalo River at mouth, Buffalo, N. Y.		Median	33,000	.....	.....	.....	.....	.....	.....	.....	.....	.....
		Average	.....	43	1,860	0.64	8	4.3	7.4	24	7.2	85
		Maximum	43,000	57	3,600	0.64	13	4.3	7.4	25	7.3	94
		Minimum	23,000	29	120	0.64	2	4.3	7.4	24	7.0	75
		No. of Samples	2	2	2	1	2	1	1	2	2	2
NiBu-38.7. Buffalo River at Michigan Ave. Bridge		Median	9,300	.....	.....	.....	.....	.....	.....	.....	.....	.....
		Average	.....	46	469	0.71	8	7.3	14.4	52	6.9	66
		Maximum	240,000	181	1,400	1.50	13	13.2	31.5	193	7.4	95
		Minimum	910	8	35	0.26	0	0	6.2	18	5.9	36
		No. of Samples	36	23	25	25	25	25	25	25	24	23
NiBu-39.4. Buffalo River at Ohio Street Bridge		Median	15,000	.....	.....	.....	.....	.....	.....	.....	.....	.....
		Average	.....	54	596	0.87	7	7.3	15.0	43	6.7	66
		Maximum	240,000	265	1,750	4.60	20	13.1	44	146	7.1	92
		Minimum	2,300	9	14	0.24	0	0	4.0	13	6.0	34
		No. of Samples	32	20	22	22	22	22	22	22	21	20
NiBu-41.3. Buffalo River at New York Central Railroad Bridge		Median	4,100	.....	.....	.....	.....	.....	.....	.....	.....	.....
		Average	.....	33	800	0.64	11	8.5	12.7	31	6.8	51
		Maximum	4,300	42	800	0.76	11	8.6	15.3	41	7.1	70
		Minimum	3,900	24	800	0.52	11	8.4	10.0	21	6.5	31
		No. of Samples	2	2	1	2	1	2	2	2	2	2
NiBu-42.4. Buffalo River at South Park Ave. Bridge		Median	19,000	.....	.....	.....	.....	.....	.....	.....	.....	.....
		Average	.....	35	179	0.51	7	9.5	10.7	25	7.0	75
		Maximum	240,000	191	1,125	1.8	25	13.9	31.5	64	7.9	101
		Minimum	2,300	2	14	0.06	0	0	2.2	11	5.7	11
		No. of Samples	30	18	21	21	21	21	21	21	20	18
NiBu-42.9. Buffalo River below Socony Vacuum Oil Co. outfalls and above National Aniline Division outfalls		Median	6,800	.....	.....	.....	.....	.....	.....	.....	.....	.....
		Average	.....	10.5	275	0.20	9	10.3	5.7	17	7.7	81
		Maximum	9,300	11	275	0.24	9	10.4	7.1	24	7.7	81
		Minimum	4,300	10	275	0.16	9	10.2	4.3	9	7.7	81
		No. of Samples	2	2	1	2	1	2	2	2	2	2
NiBu-43.4. Buffalo River at Bailey Ave. Bridge		Median	22,000	.....	.....	.....	.....	.....	.....	.....	.....	.....
		Average	.....	16	39	0.24	5	10.5	6.1	25	7.4	96
		Maximum	93,000	77	450	0.90	23	14.0	28.2	58	7.9	126
		Minimum	4,300	5	0	0.03	0	0	0.9	4	6.5	59
		No. of Samples	28	20	21	20	21	20	20	21	20	20
NiBuCz-43.4. Cazenovia Creek at Bailey Ave. Bridge, Buffalo, N. Y.		Median	9,300	.....	.....	.....	.....	.....	.....	.....	.....	.....
		Average	.....	15	35	0.21	6	10.8	5.3	25	7.4	73
		Maximum	1,100,000	93	350	1.4	22	14.4	18.6	58	7.9	113
		Minimum	2,300	3	0	0	0	0	0.6	6	6.8	51
		No. of Samples	26	17	18	17	18	17	17	18	18	17

in the vicinity of Buffalo's sewage treatment plant, and it widens to about one-third of the river's width near Strawberry Island. The median coliform content in this zone increased markedly downstream, with a median coliform M.P.N. of 4,450 per ml. and a maximum of 110,000, found near the United States shore at the Strawberry Island range. Phenols were somewhat constant with a maximum average of 17 p.p.b. found offshore from Squaw Island at the International Railroad Bridge. The westerly portion of the river from the inlet to Strawberry Island exhibits average characteristics similar to the main body of Lake Erie except for moderate sewage pollution starting downstream from Fort Erie and extending a short distance from the Canadian shore.

The pollution originating in the Buffalo area was found to proceed down the East Channel of the river. This channel exhibits a marked pollution zone along the eastern shore, although pollution exists to some extent over its entire width. This pollution zone, as measured by both coliform and phenol results, extends along the entire channel usually varying from about one-third to one-half the channel width. Within this zone the median coliform M.P.N. varied from about 3,000 to 10,000 per 100 ml., with a maximum of 110,000, with no discernible trend in values downstream. Phenols generally average between 10 and 50 p.p.b. but reached as high an average as 140 p.p.b. near the easterly shore below the Tonawandas. Although the concentration of pollutants shows somewhat the effect of wastes introduced along the Tonawanda area, the broadening of the affected zone in the river below the Tonawandas further reflects added pollution.

Oil pollution was noted on the surface of the water in the East Channel on several occasions during the course of the investigation. The oil at times extended to cover the width of the river. Efforts to locate the sources of such pollution were not successful.

The West Channel around Grand Island is of good sanitary quality. The coliform results reveal that the pollution originating along the Fort Erie shore was gradually dissipated. In general, the water was of the same quality as that in the main body of Lake Erie.

Lower Niagara River

The Niagara Falls, the lower rapids, the Whirlpool, and the Whirlpool Rapids combine to give thorough mixing of the waters in the lower Niagara River. The polluted water, from the East Channel in the upper river, is intermixed with the cleaner water from the West Channel. The bacteriological and chemical data, summarized in table N-19, pages 281 to 283, confirm this mixing and show that the pollution in the lower river was evenly dispersed throughout its cross-sectional area. Figures N-7 and N-8, following page 280, show graphically the median and maximum coliform, and average and maximum phenol results, respectively.

The median M.P.N. values per 100 ml., at the two ranges just below the Falls at the Rainbow Bridge (Ni-14.7) and the Whirlpool Rapids Bridge (Ni-12.7), varied from 430 to 1,900 with a maximum of 11,000 M.P.N. per 100 ml. found on Range Ni-12.7. The median values for samples taken on ranges from the Lewiston Bridge (Ni-8.0) to the outlet of the river varied only slightly from a value of 2,400 M.P.N. per 100 ml. The maximum M.P.N. varied from 9,300 to 46,000 on these same ranges. The discharge of raw sewage from the City of Niagara Falls, Ontario, the discharge from the Niagara Falls, New York, sewage treatment plant, and the discharge from the Hydro Electric Power Commission's power canal at Queenston combine to account for the increase in median and maximum coliform values between the Whirlpool Rapids and Lewiston Bridges.

Average values of phenol concentrations on the Ranges Ni-14.1 and 12.7 were found to be several times higher than the average values found on the four ranges below the Lewiston Bridge. The average values at the upstream ranges varied from 5 to 17 p.p.b., in comparison to average values of 0 to 2 p.p.b. being recorded below Range Ni-8.0. A maximum value of 80 p.p.b. was found on Range Ni-12.7, with 70 p.p.b. noted on Range Ni-6.8.

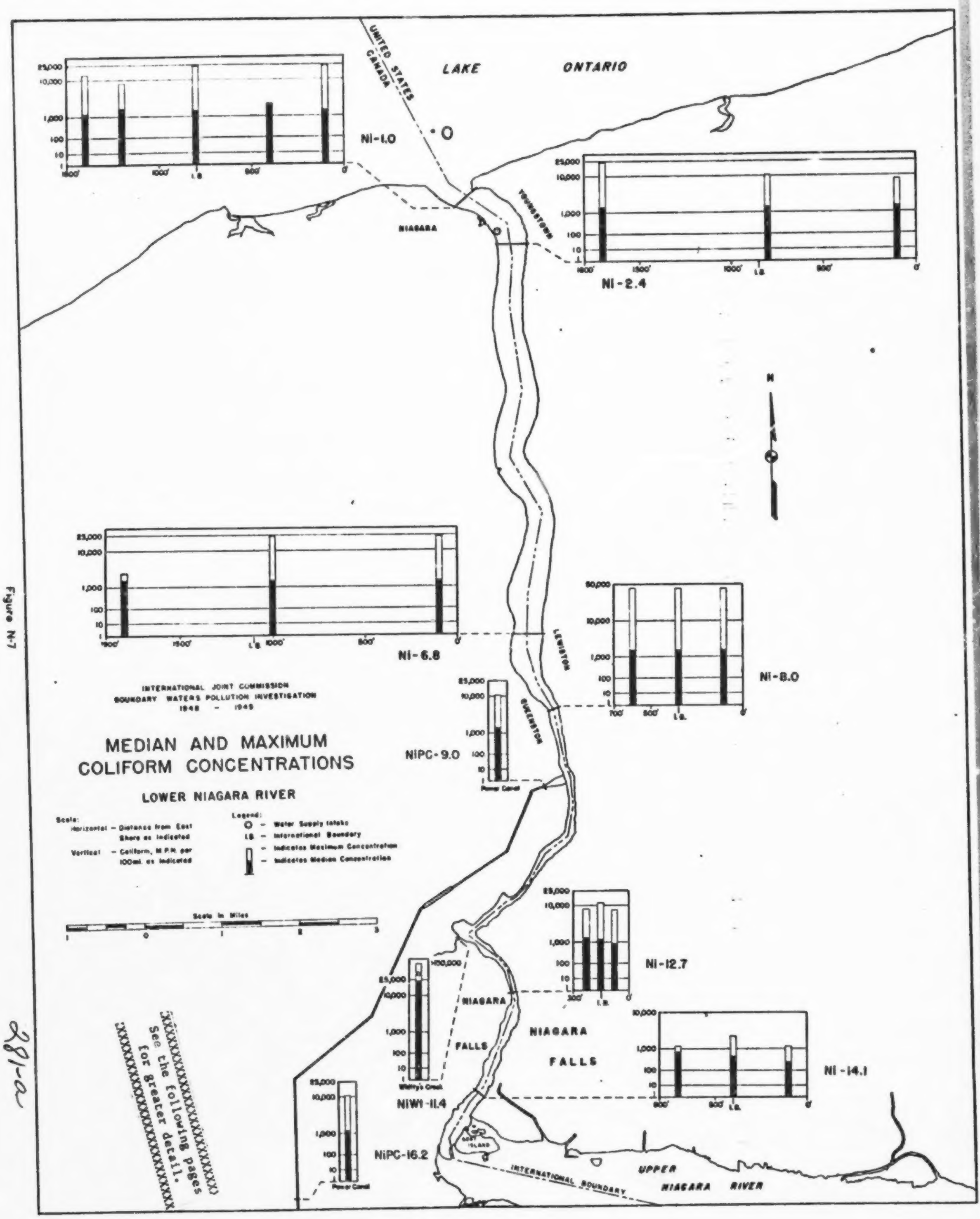
Other chemical substances showed no significant changes in passing through the lower river. Dissolved oxygen content was near saturation, and average B.O.D. values were below 2.2 p.p.m.

Lake Ontario

A U. S. Weather Bureau report of 1895 stated that the normal flow of water in Lake Ontario along the south shore is in an easterly direction. However, the summary of analytical results presented in table N-20, pages 284 to 290, does not show that the pollution from the lower Niagara River follows this direction. The median and maximum coliform, and the average and maximum phenol values are depicted in figures N-9 and N-10, following page 290.

The median M.P.N. coliform values varied from 43 to 1,100 per 100 ml. at a distance of 1.5 miles from the outlet of the Niagara River. The smaller values were noted toward the east, and the larger toward the northwest. Progressing outward from Point "0" along the fan-lake ranges, the median coliform values steadily decrease, until relatively unpolluted water prevails at a distance 10 miles from the outlet of the river. The two ranges OE and OC extending eastward showed M.P.N. values

281-a



LAKE
ONTARIO
UNITED STATES
CANADA
NI-1.0
NI-2.4
NIAGARA
YOUNGSTOWN
LEWISTON
QUEENSTON
NI-6.8
NI-8.0
NIPC-9.0
Power Canal
NI-12.7
NIAGARA
FALLS
NIAGARA
FALLS
NI-14.1
NIWI-11.4
Whitty's Creek
NIPC-16.2
GOAT ISLAND
INTERNATIONAL BOUNDARY
UPPER
NIAGARA RIVER
N
25,000
10,000
1,000
100
10
1
1800'
1500'
1000'
L.B.
500'
0'
50,000
100,000
700'
300'
Scale in Miles
1
0
1
2
3

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 - 1949

MEDIAN AND MAXIMUM
COLIFORM CONCENTRATIONS

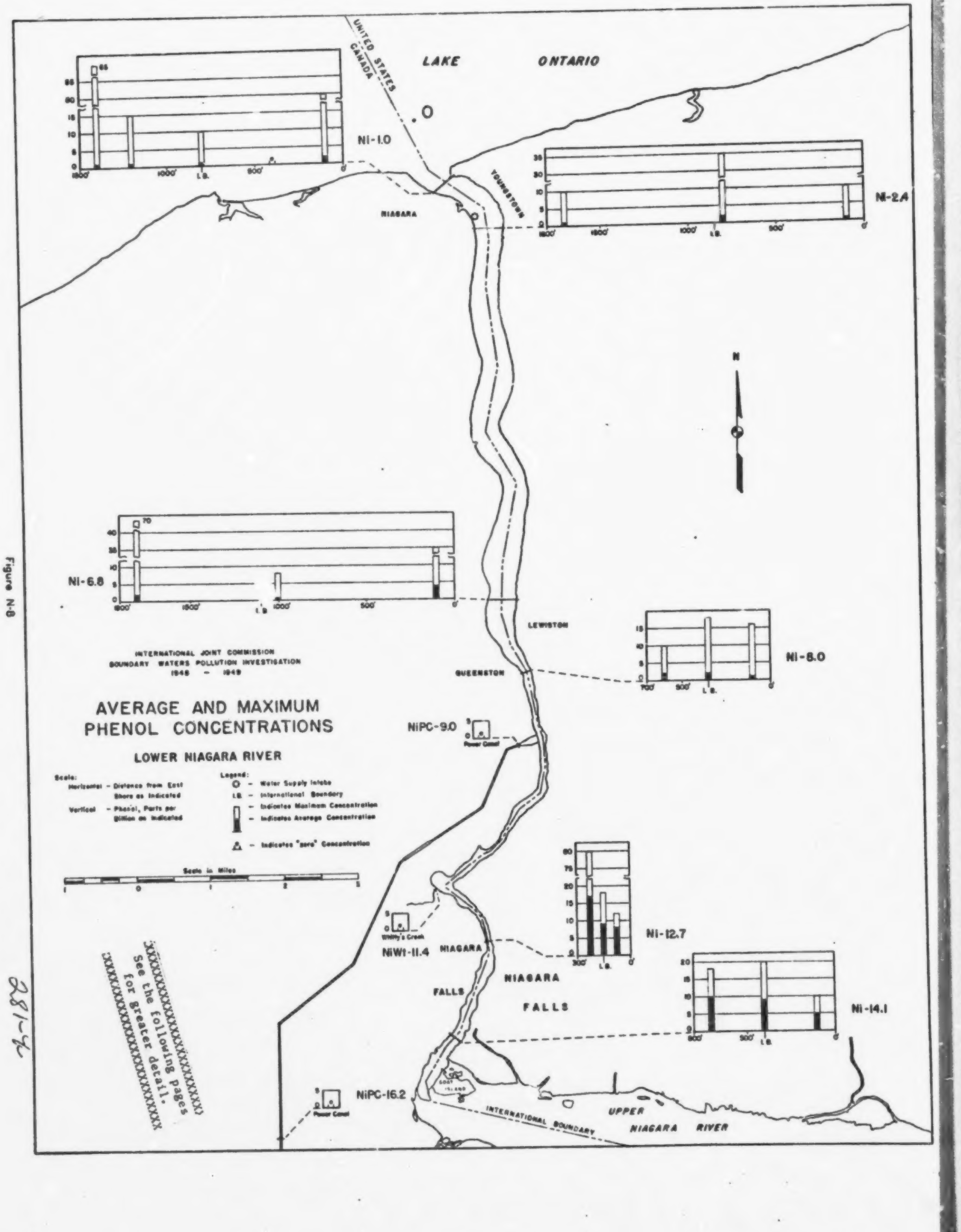
LOWER NIAGARA RIVER

Scale:
Horizontal - Distance from East Shore as Indicated
Vertical - Coliform, M.P.N. per 100ml. as Indicated

Legend:
○ - Water Supply Intake
I.B. - International Boundary
▯ - Indicates Maximum Concentration
▮ - Indicates Median Concentration

XXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXX

Figure N-7


LAKE ONTARIO
UNITED STATES
CANADA
NI-1.0
NI-2A
NIAGARA
YOUNGSTOWN
N
NI-6.8
LEWISTON
QUEENSTON
NI-8.0
NIPC-9.0
Power Canal
NIW1-11.4
Whitty's Creek
NIAGARA
NI-12.7
NIAGARA FALLS
FALLS
NI-14.1
NIPC-16.2
GOAT ISLAND
INTERNATIONAL BOUNDARY
UPPER NIAGARA RIVER
I.B.
1500'
1000'
500'
0'

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 – 1949

AVERAGE AND MAXIMUM PHENOL CONCENTRATIONS

LOWER NIAGARA RIVER

Scale:
Horizontal – Distance from East Shore as Indicated
Vertical – Phenol, Parts per Billion as Indicated

Legend:
O – Water Supply Intake
I.B. – International Boundary
▯ – Indicates Maximum Concentration
▮ – Indicates Average Concentration
△ – Indicates "zero" Concentration

Scale in Miles
1 0 1 2 3

Figure N-8

XXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXX

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varying from 23 to 587 per 100 ml., with a maximum of 1,500. In comparison, median values of from 3.6 to 2,400 per 100 ml. and a maximum of 11,000 were found on the other radial ranges. An increase in coliform values at the west end of range ON-2 through OW-8 is undoubtedly caused by bacterial pollution entering Lake Ontario in the vicinity of the old Welland Ship Canal outlet at Port Dalhousie, Ontario.

Average and maximum phenol values were low throughout the section of Lake Ontario under investigation. Average values varied from 0 to 5 p.p.b. with most values being less than 2 p.p.b. A maximum result of 85 p.p.b. was reported on range ON three miles from Point "0". With the exception of five other results in the order of 12 to 25 p.p.b., all the maximum values were less than 8 p.p.b. and over half of the maximum values were less than 3 p.p.b.

Other analytical results indicate the same conditions as shown by the phenol analyses. Turbidity and B.O.D. averages were low, and chlorides and alkalinity remained unchanged.

TABLE N-19—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LOWER NIAGARA RIVER

Sampling Range and Mileage Index	Distance from East Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_3 ppm	Temp. °C	D.O. ppm	B.O.D. 5 Day ppm	Turbidity ppm	pH	Alkalinity ppm
	0				United States Shore							
Ni-14.1. A range across the lower river at the Rainbow Bridge	100	Median	430	......	......	......	......	......	......	......	......	....
		Average	....	......	5	0.01	1	17.5	0.9	19	7.6	....
		Maximum	1,500	......	10	0.03	2	18.3	1.6	35	7.7	....
		Minimum	36	......	Trace	0	0	16.6	0.6	10	7.5	....
		No. of Samples	6	......	6	6	6	6	6	5	6	....
	400				International Boundary							
	400	Median	680	......	......	......	......	......	......	......	......	....
		Average	....	......	9	0.02	1	17.3	0.8	16	7.7	....
		Maximum	4,300	......	20	0.06	2	17.8	1.5	25	7.7	....
		Minimum	230	......	Trace	0	0	16.9	0.2	9	7.5	....
		No. of Samples	6	......	6	6	6	6	6	5	6	....
	700	Median	840	......	......	......	......	......	......	......	......	....
		Average	....	......	10	0.01	1	17.1	1.0	18	7.7	....
		Maximum	1,500	......	18	0.03	2	17.6	2.3	31	7.7	....
		Minimum	430	......	6	0	0	16.7	0.4	12	7.6	....
		No. of Samples	6	......	6	6	6	6	6	5	6	....
	800				Canadian Shore							
	0				United States Shore							
Ni-12.7. A range across the river at the Whirlpool Rapids Bridge	75	Median	....	......	......	......	......	......	......	......	......	....
		Average	930	......	8	0.02	1	16.7	1.0	18	7.7	....
		Maximum	9,300	......	12	0.03	2	17.4	1.6	30	7.7	....
		Minimum	150	......	3	0	0	16.3	0.5	10	7.5	....
		No. of Samples	8	......	7	7	7	7	7	6	7	....
	150				International Boundary				......	......	......	....
	150	Median	1,615	......	......	......	......	......	......	......	......	....
		Average	....	......	9	0.02	1	16.7	0.8	19	7.7	....
		Maximum	>11,000	......	18	0.06	2	17.3	1.1	29	7.7	....
		Minimum	230	......	3	0	0	16.2	0.5	11	7.5	....
		No. of Samples	8	......	7	7	7	6	7	6	7	....
	225	Median	1,900	......	......	......	......	......	......	......	......	....
		Average	....	......	17	0.02	1	16.8	1.0	18	7.7	....
		Maximum	9,300	......	80	0.03	2	17.3	2.1	26	7.7	....
		Minimum	230	......	4	0	0	16.3	0.7	9	7.5	....
		No. of Samples	8	......	7	7	7	6	7	6	7	....
	300				Canadian Shore							
NiWt-11.4.—Whitty's Creek at discharge to the Whirlpool, Stamford Township, Ontario		Median	24,000	......	......	......	......	......	......	......	......	....
		Average	....	34	0	1.02	17	......	2.3	20	8.7	119
		Maximum	>150,000	46	0	1.56	17	......	3.9	35	9.1	152
		Minimum	2,400	24	0	0.48	16	......	0.8	10	8.4	90
		No. of Samples	9	6	4	2	2	......	5	6	6	6

Table N-19—Summary of Average Analytical Results—Lower Niagara River—Continued

Sampling Range and Mileage Index	Distance from East Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 Day ppm	Turbidity ppm	pH	Alkalinity ppm
NiPC-9.0. Hydro Electric Power Commission's power canal at discharge to lower Niagara River at Queenston, Ontario		Median	2,000									
		Average		19	0	0.26	5	12.5	1.5	20	7.9	91
		Maximum	11,000	25	Trace	0.48	12	14.2	4.1	50	8.1	100
		Minimum	400	15	0	0.04	0	10.3	0.2	6	7.9	78
		No. of Samples	18	18	15	2	14	16	13	17	17	18
	0				United States Shore							
Ni-8.0. A range across the river at the Lewiston Bridge	100	Median	2,400									
		Average		20	1	0.02	15	11.9	1.6	7	8.0	93
		Maximum	46,000	25	16	0.44	23	17.6	4.8	30	8.5	99
		Minimum	75	18	0	0	0	10.1	0.5	2	7.7	90
		No. of Samples	48	19	44	25	31	15	15	32	32	17
	350				International Boundary							
	350	Median	2,400									
		Average		21	2	0.05	17	11.9	1.3	5	8.1	93
		Maximum	46,000	26	18	0.56	24	17.4	2.8	25	8.5	99
		Minimum	30	18	0	0	0	9.7	0.3	1	7.6	86
		No. of Samples	48	35	47	31	46	45	48	48	48	33
	600	Median	2,400									
		Average		20	2	0	15	12.8	1.1	7	8.1	94
		Maximum	46,000	25	10	0.03	23	17.4	2.0	25	8.5	98
		Minimum	<3.0	18	0	0	0	10.0	0.4	1	7.7	92
		No. of Samples	48	19	43	25	31	15	15	32	32	17
	700				Canadian Shore							
	0				United States Shore							
	450				International Boundary							
	1,250				Canadian Shore							
Ni-7.6. A range 7.6 miles above bell buoy B-1, at Canadian Steamship Lines dock at Queenston, Ontario	1,250	Median	1,600									
		Average		23	2	0.30	5	15.7	2.2	19	8.0	92
		Maximum	>15,000	28	10	0.56	10	17.2	4.0	26	8.2	98
		Minimum	460	20	0	0.04	0	13.7	1.0	8	7.9	86
		No. of Samples	9	9	8	2	8	8	7	8	8	9
	0				United States Shore							
Ni-6.8. A range 6.8 miles above bell buoy B-1, below Lewiston, N. Y., and Queenston, Ontario	100	Median	2,400									
		Average		20	4	0	16	11.6	1.6	4	8.1	94
		Maximum	24,000	24	70	0.02	22.5	14.3	2.6	14	8.5	97
		Minimum	240	18	0	0	8	10.0	0.4	1	7.7	90
		No. of Samples	34	10	32	13	18	8	8	19	19	9
	1,000	Median	2,400									
		Average		22	1	0.09	17	11.7	1.6	4	8.1	93
		Maximum	24,000	27	8	0.68	24	14.3	3.5	16	8.5	98
		Minimum	<3.0	18	0	0	8	9.8	0.4	1	7.9	86
		No. of Samples	34	26	34	18	33	34	34	35	35	25
	1,100				International Boundary							
	1,800	Median	2,400									
		Average		20	2	0	16	11.5	1.4	5	8.1	94
		Maximum	4,600	23	35	0.02	22.5	14.3	2.2	15	8.6	97
		Minimum	93	18	0	0	8	10.3	0.9	1	7.9	92
		No. of Samples	34	10	32	13	18	8	8	19	19	9
	1,900				Canadian Shore							
	0				United States Shore							
Ni-2.4. A range 2.4 miles above bell buoy B-1, above Youngstown, N. Y. and Niagara-on-the-Lake, Ontario	100	Median	2,400									
		Average		20	1	0	17	11.6	1.8	6	8.1	94
		Maximum	9,300	24	10	0.02	22.5	14.1	3.1	13	8.5	98
		Minimum	150	17	0	0	8	10.3	0.9	1	7.9	90
		No. of Samples	40	16	37	19	24	8	8	25	25	14

TABLE N-19—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LOWER NIAGARA RIVER—Continued

Sampling Range and Mileage Index	Distance from East Shore (Feet)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 Day ppm	Turbidity ppm	pH	Alkalinity ppm
Ni-2.4. (Continued)	800	Median	2,300									
		Average		21	2	0.06	18	11.3	1.6	5	8.1	93
		Maximum	11,000	27	35	0.66	24	14.1	>8.3	14	8.5	99
		Minimum	210	18	0	0	8	9.7	0.5	1	7.2	84
		No. of Samples	39	32	39	24	39	39	39	41	41	30
	850				International Boundary							
	1,700	Median	2,300									
		Average		20	1	0	17	11.7	1.6	6	8.1	94
		Maximum	24,000	28	10	0.06	22.5	13.9	3.1	18	8.5	98
		Minimum	<3.0	17	0	0	8	10.2	0.8	1	7.9	90
		No. of Samples	39	16	36	19	24	8	8	25	25	14
	1,800				Canadian Shore							
	0				United States Shore							
Ni-1.0. A range across lower Niagara River at United States Coast Guard Station, one mile from bell buoy B-1	100	Median	2,300									
		Average		20	2	0.01	17	11.7	1.3	5	8.2	94
		Maximum	24,000	24	65	0.07	23	14.0	2.0	13	8.5	100
		Minimum	93	18	0	0	8	10.4	0.7	1	7.7	84
		No. of Samples	65	19	62	24	29	12	11	31	31	16
	400	Median	4,300									
		Average		19	0	0	19	10.5	1.2	6	8.2	95
		Maximum	4,300	21	Trace	0.03	23	10.6	1.4	14	8.5	99
		Minimum	930	18	0	0	12	10.4	1.0	2	7.9	91
		No. of Samples	16	14	15	14	15	2	2	16	16	11
	800	Median	2,400									
		Average		21	1	0.04	18	11.6	1.3	4	8.1	92
		Maximum	24,000	27	10	0.66	24	14.2	4.6	14	8.5	103
		Minimum	93	17	0	0	8	9.7	0.1	1	7.2	72
		No. of Samples	69	57	67	40	59	49	55	69	68	53
	1,200	Median	2,550									
		Average		19	1	0	19	10.5	0.9	6	8.2	95
		Maximum	9,300	20	15	0.02	23	10.7	1.0	14	8.5	99
		Minimum	230	17	0	0	12	10.3	0.7	2	7.9	92
		No. of Samples	16	14	15	14	15	2	2	16	16	11
	1,400	Median	1,500									
		Average		20	1	0	17	11.5	1.1	5	8.1	94
		Maximum	15,000	23	50	0.04	23	13.8	2.0	13	8.5	98
		Minimum	<3.0	17	0	0	8	10.0	0.3	1	7.7	91
		No. of Samples	65	19	61	24	29	12	11	31	31	16
	1,500				Canadian Shore							
LOWER NIAGARA RIVER TRIBUTARIES												
NiPC-9.0. Hydro Electric Power Commission's power canal at discharge to lower Niagara River at Queenston, Ontario		Median	2,000									
		Average		19	0	0.26	5	12.5	1.5	20	7.9	91
		Maximum	11,000	25	Trace	0.48	12	14.2	4.1	50	8.1	100
		Minimum	400	15	0	0.04	0	10.3	0.2	6	7.9	78
		No. of Samples	18	18	15	2	14	16	13	17	17	18
NiPC-16.2. Hydro Electric Power Commission's power canal at Allanburg-Chippawa Highway, 1.6 miles from its junction with the Welland River		Median	1,430									
		Average		19	0	......	11	11.2	0.7	26	7.9	92
		Maximum	11,000	20	0	......	11	12.4	1.5	54	8.0	94
		Minimum	150	19	0	......	11	10.3	0	9	7.9	90
		No. of Samples	4	4	4	......	2	4	4	4	4	4
NiPCWe-18.3. Welland River 0.5 miles west of junction with Hydro Electric Power Commission's power canal		Median	2,400									
		Average		18	3	2.2	3	10.5	2.7	49	7.3	79
		Maximum	28,000	26	10	4.4	4	11.4	3.6	150	8.1	94
		Minimum	1,100	4.1	0	0.48	2	9.1	0.8	4	6.4	48
		No. of Samples	7	7	7	3	4	7	6	7	7	7

TABLE N-20—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ONTARIO

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm
"O". Point "O" is the bell buoy B-1, located about one mile from the outlet of Niagara River. It is the zero point for the radial sampling ranges in Lake Ontario	0	Median	695									
		Average		23	2	0.06	17	12.3	2.0	4	8.1	92
		Maximum	4,300	37	20	0.96	24	13.5	4.5	15	8.8	98
		Minimum	23	17	0	0	8	10.7	0.3	1	7.2	78
		No. of Samples	42	37	41	28	33	18	26	42	41	36
OW. A range westerly from point "O" on a bearing of S 76° W roughly parallel to the Canadian Shore	0.5	Median	1,100									
		Average		22	1	<0.01	20	12.4	1.4	3	8.3	95
		Maximum	2,400	22	4	0.01	24	12.9	1.7	6	8.3	98
		Minimum	150	21	0	Trace	13	11.9	1.1	1	8.3	92
		No. of Samples	10	3	10	2	5	2	3	5	5	3
	1.0	Median	1,100									
		Average		23	1	0.15	18	12.3	1.6	4	8.1	93
		Maximum	11,000	24	6	0.58	24	12.7	2.7	6	8.3	95
		Minimum	28	21	0	0	12	11.8	0.7	1	7.2	90
		No. of Samples	11	6	12	5	6	3	6	8	8	6
	2.0	Median	780									
		Average		23	2	0.03	19	11.9	0.9	3	8.3	93
		Maximum	4,600	25	6	0.10	24	12.2	1.2	5	8.3	96
		Minimum	21	20	0	0	11	11.7	0.3	1	8.2	91
		No. of Samples	10	6	9	3	8	3	6	8	8	6
	3.0	Median	1,665									
		Average		23	0	0.16	21	11.9	1.1	3	8.2	95
		Maximum	2,400	25	4	0.44	24	12.2	1.6	6	8.4	96
		Minimum	93	21	0	Trace	12	11.6	0.6	1	7.9	92
		No. of Samples	10	5	10	3	4	2	5	6	6	5
	4.0	Median	980									
		Average		23	1	Trace	19	12.3	1.4	3	8.3	92
		Maximum	4,600	26	5	Trace	24	13.0	2.3	7	8.3	96
		Minimum	43	17	0	0	12	11.5	0.8	1	8.1	88
		No. of Samples	10	7	8	2	8	3	6	8	8	7
OT. A range from the point "O" on a bearing at N 56°W	0.5	Median	1,100									
		Average		20	1	Trace	19	12.5	......	3	8.3	96
		Maximum	2,400	21	4	Trace	24	12.5	......	4	8.4	96
		Minimum	150	18	0	0	13	12.5	......	2	8.1	96
		No. of Samples	17	2	14	2	2	1	......	3	3	2
	1.0	Median	1,100									
		Average		23	1	0.18	21	12.2	1.4	3	8.2	94
		Maximum	4,600	24	6	0.68	24	12.2	2.0	7	8.3	98
		Minimum	75	18	0	0	13	12.2	0.9	1	7.9	88
		No. of Samples	19	6	17	4	4	1	4	7	7	6
	2.0	Median	1,100									
		Average		23	1	0	16	12.0	1.4	3	8.2	92
		Maximum	11,000	25	7	Trace	24	12.5	3.8	6	8.4	98
		Minimum	3.6	18	0	0	12	11.6	0.6	2	8.0	88
		No. of Samples	23	10	18	8	9	6	7	11	11	10
	3.0	Median	350									
		Average		22	1	Trace	21	11.8	1.1	2	8.3	94
		Maximum	11,000	24	6	Trace	24	11.8	1.6	3	8.5	96
		Minimum	<3.0	19	0	0	13	11.8	0.6	1	8.1	92
		No. of Samples	18	4	14	2	4	1	2	5	5	4
	4.0	Median	305									
		Average		22	1	0.04	16	12.1	1.3	3	8.2	92
		Maximum	11,000	26	5	0.36	24	13.0	2.2	9	8.4	97
		Minimum	3.6	14	0	0	11	11.7	0.6	1	7.9	88
		No. of Samples	18	15	18	10	10	8	10	16	16	15
	5.0	Median	68									
		Average		......	0	......	......	......	......	......	......	......
		Maximum	>1,500	......	Trace	......	......	......	......	......	......	......
		Minimum	<3.0	......	0	......	......	......	......	......	......	......
		No. of Samples	6	......	5	......	......	......	......	......	......	......

TABLE N-20—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ONTARIO—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm
OT. (Continued)	6.0	Median	23	....	....	....	....	....	....	....	....	....
		Average	....	23	0	0	14	12.1	1.1	2	8.1	93
		Maximum	1,100	25	Trace	0	20	12.4	1.5	2	8.2	96
		Minimum	9.1	19	0	0	10	11.7	0.8	1	8.0	90
		No. of Samples	7	6	7	6	5	4	4	6	6	6
	7.0	Median	23	....	....	....	....	....	....	....	....	....
		Average	....	....	0	....	....	....	....	....	....	....
		Maximum	>1,500	....	Trace	....	....	....	....	....	....	....
		Minimum	<3.0	....	0	....	....	....	....	....	....	....
		No. of Samples	6	....	5	....	....	....	....	....	....	....
	8.0	Median	3.6	....	....	....	....	....	....	....	....	....
		Average	....	24	1	0	13	12.1	1.2	1	8.1	93
		Maximum	460	28	4	0	19	12.8	2.0	2	8.3	96
		Minimum	<3.0	19	0	0	10	11.3	0.8	1	8.0	88
		No. of Samples	7	7	7	6	5	4	5	7	7	7
OM. A range from point "O" on a bearing of N 27°W parallel to the International Boundary	0.5	Median	1,100	....	....	....	....	....	....	....	....	....
		Average	....	....	2	Trace	14	11.4	1.2	4	8.0	....
		Maximum	2,400	....	8	Trace	14	11.4	1.2	4	8.0	....
		Minimum	93	....	0	Trace	14	11.4	1.2	4	8.0	....
		No. of Samples	4	....	4	1	1	1	1	1	1	....
	1.0	Median	>1,500	....	....	....	....	....	....	....	....	....
		Average	....	....	0	Trace	14	11.8	1.1	4	8.1	....
		Maximum	2,400	....	Trace	Trace	14	11.8	1.1	4	8.1	....
		Minimum	430	....	0	Trace	14	11.8	1.1	4	8.1	....
		No. of Samples	4	....	4	1	1	1	1	1	1	....
	2.0	Median	1,800	....	....	....	....	....	....	....	....	....
		Average	....	....	1	Trace	14	12.1	0.9	4	8.1	....
		Maximum	2,400	....	3	Trace	14	12.1	0.9	4	8.1	....
		Minimum	430	....	0	Trace	14	12.1	0.9	4	8.1	...
		No. of Samples	4	....	4	1	1	1	1	1	1	....
	3.0	Median	1,800	....	....	....	....	....	....	....	....	....
		Average	....	19	1	Trace	14	12.0	0.9	3	8.0	90
		Maximum	2,400	19	3	Trace	14	12.0	1.3	4	8.1	90
		Minimum	750	19	0	Trace	14	12.0	0.5	3	7.9	90
		No. of Samples	4	2	4	1	1	1	2	3	3	2
	4.0	Median	460	....	....	....	....	....	....	....	....	....
		Average	....	24	1	Trace	19	12.0	0.8	3	8.1	90
		Maximum	>1,500	24	4	Trace	23	12.0	0.8	4	8.1	90
		Minimum	230	24	0	0	14	12.0	0.8	1	8.1	90
		No. of Samples	4	1	4	2	2	1	1	2	2	1
	5.0	Median	1,100	....	....	....	....	....	....	....	....	....
		Average	....	....	0	....	....	....	....	....	....	....
		Maximum	1,100	....	0	....	....	....	....	....	....	....
		Minimum	1,100	....	0	....	....	....	....	....	....	....
		No. of Samples	3	....	3	....	....	....	....	....	....	....
	6.0	Median	1,215	....	....	....	....	....	....	....	....	....
		Average	....	20	1	0.01	14	12.1	0.7	3	8.0	90
		Maximum	>1,500	20	3	0.01	14	12.1	0.8	3	8.2	90
		Minimum	460	19	0	0.01	14	12.1	0.5	3	7.9	90
		No. of Samples	4	2	4	1	1	1	2	3	3	2
	8.0	Median	19	....	....	....	....	....	....	....	....	....
		Average	....	23	Trace	Trace	18	11.8	0.5	2	8.4	92
		Maximum	23	23	Trace	Trace	22	11.8	0.5	2	8.5	92
		Minimum	15	23	0	0	14	11.8	0.5	1	8.2	92
		No. of Samples	2	1	2	2	2	1	1	2	2	1
	10.0	Median	3.6	....	....	....	....	....	....	....	....	....
		Average	....	....	2	Trace	14	13.1	0.7	2	8.0	....
		Maximum	7.3	....	3	Trace	14	13.1	0.7	2	8.0	....
		Minimum	<3.0	....	0	Trace	14	13.1	0.7	2	8.0	....
		No. of Samples	2	....	2	1	1	1	1	1	1	....

TABLE N-20—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ONTARIO—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm
ON. A range from point "O" on a bearing of N 3°E	0.5	Median	240	...	...	...	...	...	...	...	...	...
		Average	...	20	1	0.01	18	12.0	1.5	5	8.2	95
		Maximum	4,600	23	16	0.06	23	13.6	3.1	15	8.5	97
		Minimum	23	18	0	0	9	10.9	0.7	2	8.0	93
		No. of Samples	30	6	26	8	8	3	4	9	9	4
	1.0	Median	240	...	...	...	...	...	...	...	...	...
		Average	...	20	2	0	18	12.2	1.0	4	8.3	95
		Maximum	4,600	20	14	0.02	23	13.6	1.0	12	8.5	96
		Minimum	9.1	18	0	0	9	11.3	0.9	2	8.0	93
		No. of Samples	30	4	25	7	8	3	2	8	8	3
	2.0	Median	430	...	...	...	...	...	...	...	...	...
		Average	...	23	1	0.02	18	12.0	1.5	3	8.1	92
		Maximum	11,000	28	6	0.48	23	13.6	3.8	10	8.5	96
		Minimum	3.6	19	0	0	9	11.2	0.8	1	6.7	86
		No. of Samples	35	25	32	23	25	10	16	29	29	24
	3.0	Median	460	...	...	...	...	...	...	...	...	...
		Average	...	21	3	0	18	12.4	1.0	4	8.3	94
		Maximum	11,000	25	85	Trace	23	13.4	1.3	13	8.5	95
		Minimum	23	18	0	0	6	11.2	0.5	2	8.0	90
		No. of Samples	29	5	26	7	8	4	4	9	9	4
	4.0	Median	430	...	...	...	...	...	...	...	...	...
		Average	...	22	1	0.05	17	12.1	1.5	3	8.2	92
		Maximum	2,400	26	6	0.58	23	13.4	3.5	9	8.6	99
		Minimum	9.1	17	0	0	7	11.2	0.3	1	7.3	78
		No. of Samples	29	26	28	19	23	12	20	29	29	25
	5.0	Median	93	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	...	...	...	...	...	...
		Maximum	>1,500	...	Trace	...	...	...	...	...	...	...
		Minimum	<3.0	...	0	...	...	...	...	...	...	...
		No. of Samples	10	...	9	...	...	...	...	...	...	...
	6.0	Median	33	...	...	...	...	...	...	...	...	...
		Average	...	23	0	0.01	13	12.0	1.5	3	8.1	92
		Maximum	1,100	24	Trace	0.12	19	13.0	2.7	8	8.4	96
		Minimum	<[illegible]	18	0	0	9	11.3	0.7	1	8.0	88
		No. of Samples	12	10	11	10	8	7	7	10	10	9
	7.0	Median	43	...	...	...	...	...	...	...	...	...
		Average	...	...	1	...	...	...	...	...	...	...
		Maximum	460	...	4	...	...	...	...	...	...	...
		Minimum	<3.0	...	0	...	...	...	...	...	...	...
		No. of Samples	9	...	8	...	...	...	...	...	...	...
	8.0	Median	15	...	...	...	...	...	...	...	...	...
		Average	...	22	1	0.01	14	12.1	1.1	3	8.1	92
		Maximum	430	25	7	0.06	24	13.1	1.7	10	8.7	96
		Minimum	<3.0	18	0	0	8	11.0	0.4	1	7.2	90
		No. of Samples	11	11	10	10	10	7	7	11	11	10
	10.0	Median	15	...	...	...	...	...	...	...	...	...
		Average	...	22	2	0.3	12	13.2	0.9	6	8.1	96
		Maximum	64	25	3	0.6	16	13.2	0.9	7	8.1	96
		Minimum	>3.6	18	0	0	7	13.2	0.9	4	8.0	96
		No. of Samples	3	2	2	2	2	1	1	2	2	1
OC. A range from point "O" on a bearing N 45°E	0.5	Median	150	...	...	...	...	...	...	...	...	...
		Average	...	42	1	1.5	9	13.5	0.9	5	7.8	89
		Maximum	460	42	6	3.0	10	13.5	0.9	6	7.9	89
		Minimum	7.3	42	0	0	8	13.5	0.9	3	7.6	89
		No. of Samples	5	1	5	2	2	1	1	2	2	1
	1.0	Median	84	...	...	...	...	...	...	...	...	...
		Average	...	38	0	1.5	9	13.2	0.6	5	7.9	88
		Maximum	460	38	Trace	3.0	10	13.2	0.6	7	7.9	88
		Minimum	23	38	0	0	8	13.2	0.6	3	7.8	88
		No. of Samples	6	1	6	2	2	1	1	2	2	1

TABLE N-20—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ONTARIO—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm
OC. (Continued)	2.0	Median	43	....	....	....	....	....	....	....	....	....
		Average	....	24	5	0.18	11	12.1	1.3	2	8.0	91
		Maximum	93	27	25	0.92	16	13.2	1.9	5	8.1	97
		Minimum	<3.0	23	0	0	6	10.9	0.6	1	7.9	88
		No. of Samples	5	4	5	5	3	2	2	5	4	4
	3.0	Median	93	....	....	....	....	....	....	....	....	....
		Average	....	....	2	0.3	8	13.2	0.5	3	8.0	....
		Maximum	460	....	8	0.6	10	13.2	0.5	4	8.0	....
		Minimum	<3.0	....	0	0	6	13.2	0.5	2	7.9	....
		No. of Samples	5	....	5	2	2	1	1	2	2	....
	4.0	Median	430	....	....	....	....	....	....	....	....	....
		Average	....	24	1	0.08	14	11.9	0.9	2	8.1	89
		Maximum	>1,500	24	3	0.48	24	13.3	1.2	3	8.3	90
		Minimum	<3.0	23	0	0	6	10.5	0.5	1	7.9	88
		No. of Samples	5	4	5	6	4	2	2	6	4	4
	5.0	Median	310	....	....	....	....	....	....	....	....	....
		Average	....	....	0	....	....	....	....	....	....	....
		Maximum	1,100	....	0	....	....	....	....	....	....	....
		Minimum	75	....	0	....	....	....	....	....	....	....
		No. of Samples	4	....	4	....	....	....	....	....	....	....
	6.0	Median	240	....	....	....	....	....	....	....	....	....
		Average	....	24	1	0.11	10	12.0	0.9	2	8.0	89
		Maximum	1,100	24	3	0.44	16	13.3	1.0	3	8.1	90
		Minimum	3.6	23	0	0	5	10.6	0.7	1	7.9	88
		No. of Samples	5	2	5	4	3	2	2	4	3	2
	7.0	Median	23	....	....	....	....	....	....	....	....	....
		Average	....	24	0	0	16	11.7	1.7	1	7.9	90
		Maximum	460	24	0	0	16	11.7	1.7	1	7.9	90
		Minimum	23	24	0	0	16	11.7	1.7	1	7.9	90
		No. of Samples	3	1	3	1	1	1	1	1	1	1
	8.0	Median	80	....	....	....	....	....	....	....	....	....
		Average	....	24	0	0.11	13	13.4	0.4	2	8.2	89
		Maximum	>1,100	24	Trace	0.44	24	13.4	0.4	3	8.5	90
		Minimum	<3.0	23	0	0	6	13.4	0.4	1	7.9	88
		No. of Samples	4	2	4	4	3	1	1	4	3	2
	10.0	Median	43	....	....	....	....	....	....	....	....	....
		Average	....	....	0	0.15	8	13.5	0.8	3	8.0	....
		Maximum	240	....	Trace	0.30	10	13.5	0.8	4	8.2	....
		Minimum	3.6	....	0	0	6	13.5	0.8	1	7.7	....
		No. of Samples	3	....	3	2	2	1	1	2	2	....
OE. A range easterly from point "O" on a bearing of N 75°E	0.5	Median	43	....	....	....	....	....	....	....	....	....
		Average	....	20	1	0	21	12.2	1.1	3	8.5	95
		Maximum	1,500	22	6	Trace	23	12.2	1.1	4	8.6	95
		Minimum	<3.0	19	0	0	16	12.2	1.1	2	8.4	94
		No. of Samples	16	4	14	4	5	1	1	5	5	3
	1.0	Median	23	....	....	....	....	....	....	....	....	....
		Average	....	22	1	0.08	19	11.3	1.6	3	8.3	91
		Maximum	1,100	24	6	0.36	23	12.5	2.1	4	8.5	95
		Minimum	3.6	19	0	0	12	10.6	1.1	1	8.0	88
		No. of Samples	17	8	18	8	7	3	5	9	9	7
	1.5	Median	48	....	....	....	....	....	....	....	....	....
		Average	....	20	0	0	22	....	....	2	8.5	95
		Maximum	93	20	0	0	23	....	....	2	8.5	96
		Minimum	3.6	19	0	0	22	....	....	2	8.4	94
		No. of Samples	4	4	4	3	4	....	....	4	4	3
	2.0	Median	43	....	....	....	....	....	....	....	....	....
		Average	....	22	1	0	20	11.6	1.1	3	8.3	94
		Maximum	1,100	27	6	Trace	23	11.6	1.5	4	8.5	96
		Minimum	<3.6	20	0	0	14	11.5	0.2	1	8.0	88
		No. of Samples	17	10	15	7	10	2	6	12	10	10

TABLE N-20—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ONTARIO—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N_2 ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm
OE. (Continued)	3.0	Median	23	...	...	...	...	...	...	...	...	...
		Average	...	21	1	0.09	21	12.2	1.2	3	8.4	93
		Maximum	1,100	24	6	0.26	23	12.9	1.6	6	8.6	95
		Minimum	3.6	20	0	0	16	11.5	0.8	2	8.1	88
		No. of Samples	17	5	16	6	5	2	3	7	7	5
	4.0	Median	23	...	...	...	...	...	...	...	...	...
		Average	...	22	1	0	20	11.6	1.5	3	8.3	93
		Maximum	1,100	25	6	0.02	23	12.6	4.3	6	8.5	98
		Minimum	<3.0	17	0	0	13.5	10.8	0	1	7.9	90
		No. of Samples	17	13	15	8	13	4	9	15	13	13
	5.0	Median	120	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	...	...	...	...	...	...
		Maximum	150	...	Trace	...	...	...	...	...	...	...
		Minimum	43	...	0	...	...	...	...	...	...	...
		No. of Samples	4	...	4	...	...	...	...	...	...	...
	6.0	Median	75	...	...	...	...	...	...	...	...	...
		Average	...	23	Trace	0	15	11.4	1.0	2	8.0	90
		Maximum	93	23	Trace	0	16	12.0	1.1	3	8.0	92
		Minimum	9.1	23	0	0	13	10.8	0.9	1	7.9	88
		No. of Samples	3	4	3	4	2	2	2	4	2	4
	7.0	Median	93	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	...	...	...	...	...	...
		Maximum	240	...	Trace	...	...	...	...	...	...	...
		Minimum	23	...	0	...	...	...	...	...	...	...
		No. of Samples	3	...	3	...	...	...	...	...	...	...
	8.0	Median	43	...	...	...	...	...	...	...	...	...
		Average	...	23	Trace	0	13	11.9	0.4	2	8.0	90
		Maximum	93	24	Trace	0	13	11.9	0.4	2	8.0	92
		Minimum	9.1	22	0	0	13	11.9	0.4	2	8.0	88
		No. of Samples	3	3	3	3	1	1	1	3	1	3
OW-4—OT-4. A range from mile 4 on Range OW to mile 4 on Range OT	1.0	Median	1,100	...	...	...	...	...	...	...	...	...
		Average	...	22	1	0.15	19	11.8	2.1	4	8.2	94
		Maximum	11,000	24	7	0.44	24	11.8	2.6	7	8.4	95
		Minimum	23	20	0	0	13	11.8	1.6	1	7.9	92
		No. of Samples	9	3	9	3	2	1	2	4	4	3
	2.0	Median	1,100	...	...	...	...	...	...	...	...	...
		Average	...	23	1	Trace	21	11.9	1.3	2	8.3	93
		Maximum	4,600	25	6	Trace	24	11.9	2.0	3	8.4	96
		Minimum	15	21	0	Trace	13	11.9	0.6	1	8.3	88
		No. of Samples	9	3	7	1	4	1	2	4	4	3
OE-4—ON-4. A range from mile 4 on Range OE to mile 4 on Range ON	1.5	Median	150	...	...	...	...	...	...	...	...	...
		Average	...	22	1	0.12	21	11.0	1.1	3	8.3	93
		Maximum	1,100	25	6	0.48	23	11.0	1.4	6	8.5	96
		Minimum	3.6	20	0	0	16	11.0	0.8	2	7.9	88
		No. of Samples	13	5	13	6	5	1	3	7	7	5
	3.0	Median	1,100	...	...	...	...	...	...	...	...	...
		Average	...	20	2	0	21	11.1	1.2	3	8.4	95
		Maximum	11,000	20	12	0	23	11.1	1.2	4	8.5	96
		Minimum	3	20	0	0	16	11.1	1.2	2	8.4	94
		No. of Samples	13	3	11	4	5	1	1	5	5	3
OE-8—ON-8. A range from mile 8 to Range OE to mile 8 on Range ON	1.0	Median	33	...	...	...	...	...	...	...	...	...
		Average	...	...	0	...	...	...	...	...	...	...
		Maximum	43	...	0	...	...	...	...	...	...	...
		Minimum	23	...	0	...	...	...	...	...	...	...
		No. of Samples	2	...	2	...	...	...	...	...	...	...
	2.0	Median	33	...	...	...	...	...	...	...	...	...
		Average	...	24	4	0	...	...	...	2	...	90
		Maximum	43	24	8	0	...	...	...	2	...	90
		Minimum	23	24	0	0	...	...	...	2	...	90
		No. of Samples	2	1	2	1	...	...	...	1	...	1

TABLE N-20—SUMMARY OF AVERAGE ANALYTICAL RESULTS—LAKE ONTARIO—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N₃ ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm
OE-8—ON-8. (Continued)	3.0	Median	241	......	......	......	......	......	......	......	......	......
		Average	......	......	0	......	......	......	......	......	......	......
		Maximum	460	......	0	......	......	......	......	......	......	......
		Minimum	23	......	0	......	......	......	......	......	......	......
		No. of Samples	2	......	2	......	......	......	......	......	......	......
	4.0	Median	587	......	......	......	......	......	......	......	......	......
		Average	......	23	0	0	13	11.8	0.9	2	8.0	91
		Maximum	1,100	23	0	0	13	11.8	0.9	2	8.0	92
		Minimum	75	23	0	0	13	11.8	0.9	2	8.0	90
		No. of Samples	2	2	2	2	1	1	1	2	1	2
	6.0	Median	49	......	......	......	......	......	......	......	......	......
		Average	......	......	Trace	......	......	......	......	......	......	......
		Maximum	75	......	Trace	......	......	......	......	......	......	......
		Minimum	23	......	0	......	......	......	......	......	......	......
		No. of Samples	2	......	2	......	......	......	......	......	......	......
ON-2 through OW-8. A range having its zero mileage at mile 2 on Range ON and extended westward through mile 8 on Range OW for a distance of 12 miles	1.0	Median	2,400	......	......	......	......	......	......	......	......	......
		Average	......	......	Trace	......	......	......	......	......	......	......
		Maximum	4,600	......	Trace	......	......	......	......	......	......	......
		Minimum	460	......	0	......	......	......	......	......	......	......
		No. of Samples	5	......	3	......	......	......	......	......	......	......
	1.1			Inter	nation	al Bou	ndary					
	2.0			This Resul	point ts are	coinci includ	des wi ed wit	th sa h thos	mplin e for	g po OT-	int O 2.	T-
	3.0	Median	2,400	......	......	......	......	......	......	......	......	......
		Average	......	......	0	......	......	......	......	......	......	......
		Maximum	11,000	......	0	......	......	......	......	......	......	......
		Minimum	1,100	......	0	......	......	......	......	......	......	......
		No. of Samples	5	......	3	......	......	......	......	......	......	......
	4.0	Median	1,300	......	......	......	......	......	......	......	......	......
		Average	......	......	0	......	......	......	......	......	......	......
		Maximum	>15,000	......	0	......	......	......	......	......	......	......
		Minimum	1,100	......	0	......	......	......	......	......	......	......
		No. of Samples	4	......	3	......	......	......	......	......	......	......
	5.0	Median	4,600	......	......	......	......	......	......	......	......	......
		Average	......	......	0	......	......	......	......	......	......	......
		Maximum	4,600	......	0	......	......	......	......	......	......	......
		Minimum	460	......	0	......	......	......	......	......	......	......
		No. of Samples	4	......	3	......	......	......	......	......	......	......
	6.0	Median	7,800	......	......	......	......	......	......	......	......	......
		Average	......	24	0	0	20	......	......	1	8.3	93
		Maximum	11,000	25	Trace	0	21	......	......	2	8.5	94
		Minimum	460	23	0	0	20	......	......	1	8.1	92
		No. of Samples	4	4	4	4	4	......	......	4	4	4
	7.0	Median	3,500	......	......	......	......	......	......	......	......	......
		Average	......	......	Trace	......	......	......	......	......	......	......
		Maximum	11,000	......	Trace	......	......	......	......	......	......	......
		Minimum	1,100	......	0	......	......	......	......	......	......	......
		No. of Samples	4	......	3	......	......	......	......	......	......	......
	8.0	Median	>9,800	......	......	......	......	......	......	......	......	......
		Average	......	......	0	......	......	......	......	......	......	......
		Maximum	>15,000	......	Trace	......	......	......	......	......	......	......
		Minimum	43	......	0	......	......	......	......	......	......	......
		No. of Samples	4	......	4	......	......	......	......	......	......	......
	9.0	Median	571	......	......	......	......	......	......	......	......	......
		Average	......	......	0	......	......	......	......	......	......	......
		Maximum	>15,000	......	Trace	......	......	......	......	......	......	......
		Minimum	3.6	......	0	......	......	......	......	......	......	......
		No. of Samples	4	......	3	......	......	......	......	......	......	......

Table N-20—Summary of Average Analytical Results—Lake Ontario—Continued

Sampling Range and Location	Station (Miles)		Coliforms M.P.N. per 100 ml.	Chlorides ppm	Phenols ppb	Amm. as N₂ ppm	Temp. °C	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm
ON-2 through OW-8. (Continued)	10.0	Median	587									
		Average	......	......	0	......	......	......	......	......	......	......
		Maximum	11,000	......	Trace	......	......	......	......	......	......	......
		Minimum	23	......	0	......	......	......	......	......	......	......
		No. of Samples	4	......	4	......	......	......	......	......	......	......
	11.0	Median	3,500									
		Average	......	......	Trace	......	......	......	......	......	......	......
		Maximum	>15,000	......	Trace	......	......	......	......	......	......	......
		Minimum	3.0	......	0	......	......	......	......	......	......	......
		No. of Samples	4	......	4	......	......	......	......	......	......	......
	12.0	Median	1,205									
		Average	......	24	3	0	21	......	......	2	8.2	92
		Maximum	4,600	25	6	0	21	......	......	2	8.4	94
		Minimum	<3.0	23	0	0	20	......	......	1	8.1	88
		No. of Samples	4	4	4	4	4	......	......	4	4	4

Comparisons—1913 and 1948-1949 Results

Many sampling ranges on the upper and lower Niagara River were common to both the 1913 and the present investigations. Therefore, it is possible to compare the conditions then and now. However, it is difficult to compare the lake data of the two investigations because of the paucity of corresponding sampling points in Lake Erie and Lake Ontario. Since the previous examination was essentially a bacteriological one, it is only possible to compare the coliform results. Table N-21, page 291, records the results of the two investigations at corresponding sampling points in these waters. These comparisons can be approximate only since averages were used in the 1913 results and medians in the present. The former tends to give greater weight to abnormal results. Furthermore, the 1913 results are probably high because the tests were "presumptive" only. The *B. coli* index of the 1913 results has been changed to the M.P.N. index by applying a factor of 2.4 to the former.

Table N-21 indicates that the bacterial pollution of the main body of Lake Erie is the same as in 1913. However, the load in the upper Niagara River on the United States side shows a marked reduction. The sewage treatment plants placed in operation since 1913 are responsible for this reduction in bacterial pollution. The construction of trunk sewers has altered the points of discharge. The pollution along the Canadian shore in the upper river is slightly higher than that shown in the earlier investigation. A substantial coliform reduction is noted in the lower Niagara River. The pollution load at the present time is shown to be uniform, whereas the 1913 average results were somewhat erratic. This same reduction is reflected in Lake Ontario within an area of about two miles from the outlet of the Niagara River.

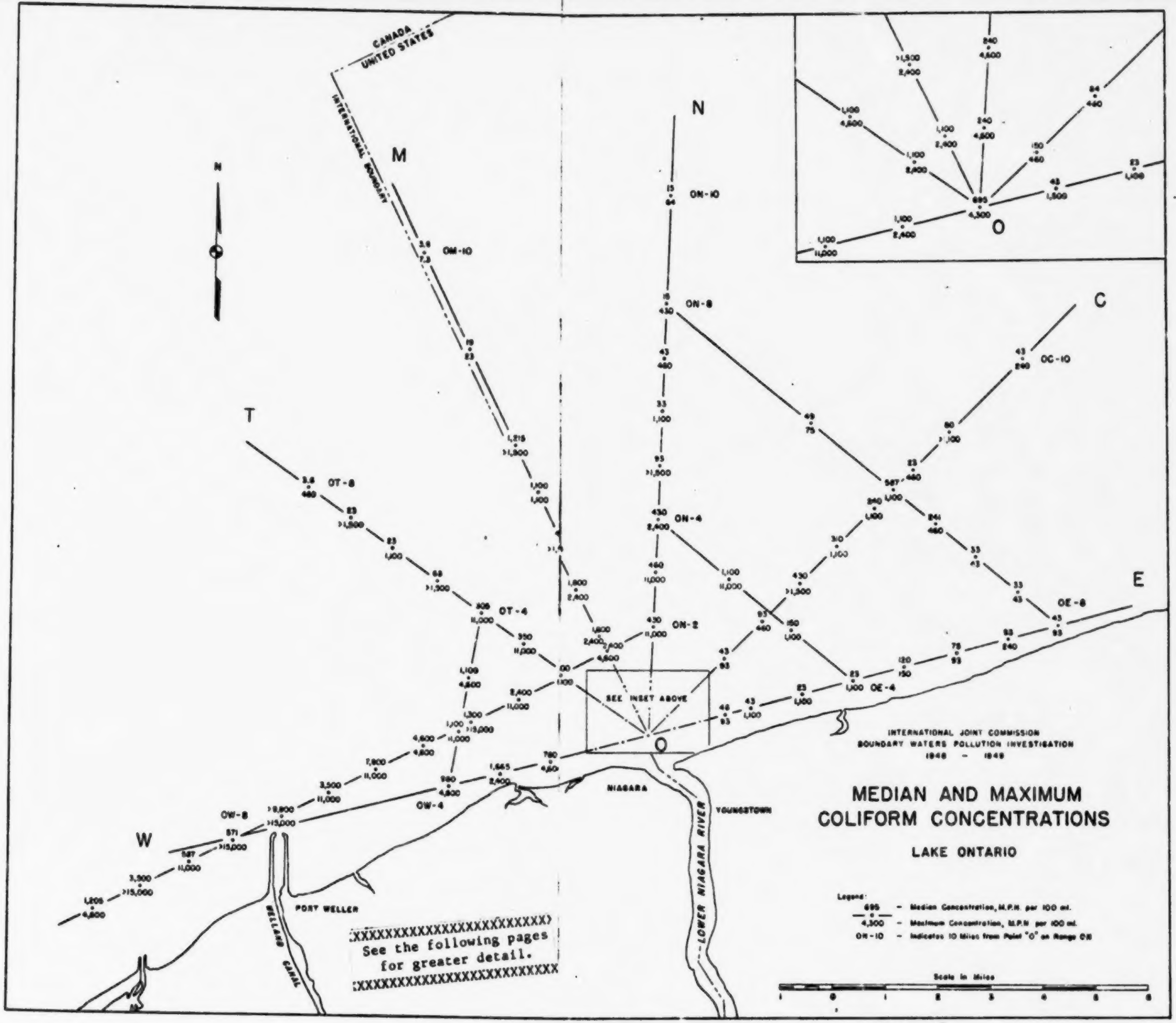
Supplementary Information on Pollution Effects

In addition to the effect of pollution on these boundary waters shown by the analytical results of samples collected during the survey, supplementary material has been obtained from various sources and from special studies. This information has been compiled in a further effort to evaluate the effects of pollution.

Transboundary Movement of Pollution

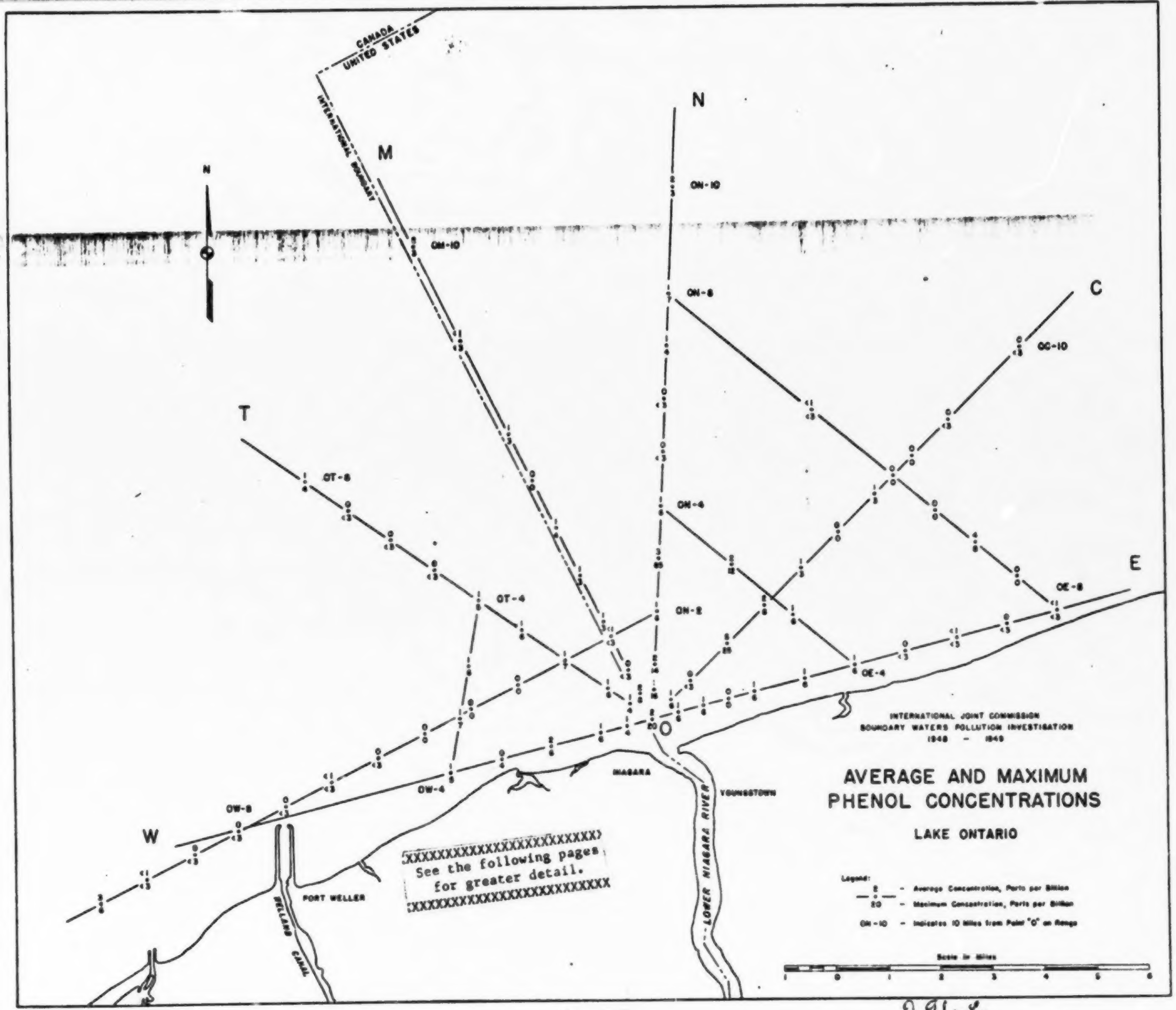
The treaty of 1909 between the two countries stated that "the boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other." An answer was therefore sought as to whether transboundary pollution was taking place, to what extent, and in what localities. The information utilized in answering these questions was obtained from the analytical results, float studies, and a review of the data from various sources.

In Lake Erie, the general trend of both coliform and phenol results indicates that major pollution is normally confined to a relatively narrow path along the United States shore. However, certain high phenol results along the Canadian shore, together with the movement of a number of floats from either side to the other, suggest that transboundary currents may prevail during periods of abnormal meteorological conditions. An undertow along the east shore of Lake Erie, for example, such as accompanies heavy southwesterly winds or a seiche, would tend to spread the pollution introduced along the United States shore into the main body of Lake Erie toward the International


INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1946 - 1948
MEDIAN AND MAXIMUM
COLIFORM CONCENTRATIONS
LAKE ONTARIO
Legend:
695 - Median Concentration, M.P.N. per 100 ml.
4,300 - Maximum Concentration, M.P.N per 100 ml.
ON-10 - Indicates 10 Miles from Point "O" on Range ON
Scale in Miles
1
0
1
2
3
4
5
6
N
CANADA
UNITED STATES
INTERNATIONAL BOUNDARY
M
N
C
E
T
W
O
OM-10
ON-10
ON-8
ON-4
ON-2
OC-10
OE-8
OE-4
OT-8
OT-4
OW-8
OW-4
SEE INSET ABOVE
NIAGARA
YOUNGSTOWN
LOWER NIAGARA RIVER
PORT WELLER
WELLAND CANAL

XXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXX

Figure N-9


CANADA
UNITED STATES
INTERNATIONAL BOUNDARY
N
M
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C
E
W
O
ON-10
ON-8
ON-4
ON-2
OM-10
OT-8
OT-4
OC-10
OE-8
OE-4
OW-4
OW-8
NIAGARA
YOUNGSTOWN
LOWER NIAGARA RIVER
PORT WELLER
WELLAND CANAL
Legend:
2 - Average Concentration, Parts per Billion
20 - Maximum Concentration, Parts per Billion
ON-10 - Indicates 10 Miles from Point "O" on Range
Scale in Miles
1
0
1
2
3
4
5
6

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 - 1949

AVERAGE AND MAXIMUM
PHENOL CONCENTRATIONS

LAKE ONTARIO

XXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXX

Figure N-10

291-X

TABLE N-21—AVERAGE COLIFORM RESULTS, 1913 AND 1948-1949

Stream	Location and Range	M.P.N. per 100 Ml.	
		1913 Average*	1948-1949 Median*
Lake Erie	Main Body	<5	<10
	Buffalo Outer Harbor:		
	Range BA—Breakwater	50	120
	Range FH—Breakwater	79	120
	Range UL—1,000 feet from shore	1,340	1,900
Upper Niagara River	Buffalo Intake (Ni-37.7)	0.7	3.6
	Bird Island Ferry Dock (Ni-35.2):		
	United States Side	3,100	150
	International Boundary	14	3.6
	Canadian Side	13.5	23
	International Bridge (Ni-34.3):		
	United States Side	29,600	2,400
	International Boundary	6.2	430
	Canadian Side	19.7	23
	Strawberry Island (Ni-32.5):		
	Head of Island	24	8.2
	International Boundary	1.0	9.1
	Canadian Side	210	30
	South Grand Island Bridge (Ni-29.0):		
	United States Side	12,700	3,900
	Grand Island Side	9.6	31
	North Grand Island Bridge (Ni-19.3):		
	United States Side	50,000	9,300
	Center of East Channel	15,600	930
	Grand Island Side	615	43
	Beaver Island State Park (Ni-26.7):		
	Grand Island Side	7.2	9.1
	Canadian Side	7.2	445
	Navy Island (Ni-20.0):		
	Navy Island Side	84	23
	Canadian Side	94	190
	International Branch (Ni-19.4):		
	Grand Island Side	700	23
	International Boundary	87	19
Lower Niagara River	Lewiston Bridge (Ni-8.0):		
	United States Side	1,890	2,400
	International Boundary	7,260	2,400
	Canadian Side	756	2,400
	Above Youngstown (Ni-2.4):		
	United States Side	45,200	2,400
	International Boundary	42,500	2,300
	Canadian Side	14,780	2,300
	Outlet of River (Ni-1.0):		
	United States Side	11,600	2,300
	International Boundary	57,600	4,300
	Canadian Side	31,600	2,400
Lake Ontario	Point "O"	15,360	695
	On OT. 1 mile from Point "O"	3,240	1,100
	On OC. 1 mile from Point "O"	10,200	84
	On OE. 1 mile from Point "O"	1,400	23
	On OW-4-OT-4. 2 miles from OW-4	132	1,100
	On OM. 2 miles from Point "O"	1,510	1,800
	On ON. 2 miles from Point "O"	2,500	430
	On OC. 2 miles from Point "O"	910	43
	On OT. 7 miles from Point "O"	18	23
	On OM. 10 miles from Point "O"	9.6	3.6
	On OC. 10 miles from Point "O"	74.5	43

*These comparisons must be considered as approximate only.

Boundary. That this does occur is evidenced by the widening of the zone of pollution during such storm periods.

The spread of pollution across the boundary in the upper Niagara River is restricted by the high velocity of flow. The analytical results indicate that normally the pollution zone along the eastern shore is confined within United States waters and consequently to the East Channel of the river. The westerly portion of the river is influenced, however, by storm conditions in Lake Erie which affect the quality of the main body of the lake. Ice jams along the river and strong winds may alter normal flow conditions but there is no record of the West Channel of the river being affected by the polluted zone along the United States shore. This is substantiated by the analytical results.

In the lower Niagara River, cross-currents in the rapids and Whirlpool effect a thorough mixing of waters. Analyses of the water show that pollution is uniformly dispersed across each range along the lower river. Thus, pollution is transferred across the boundary, while at the same time, the full diluting capacity of the river is afforded.

The effect of the pollution persists into Lake Ontario for some 8 to 10 miles from the river outlet, and there is no pronounced tendency of flow from either side of the boundary to the other.

Municipal Water Supplies

The public health hazard or burden placed by pollution on the public water supplies of the communities bordering on the boundary waters was evaluated during this investigation. Special studies involving the sampling and analysis of the raw waters at the purification plants were undertaken by the field staffs, the results being summarized in table N-22. The water supplies are located in the upper Niagara River except for one near the United States side of Lake Erie and another near the Canadian side at the outlet of the lower river. The operating records of the major treatment plants were also reviewed. These studies show the local conditions at each plant as well as the progressive changes in water quality along the Niagara River.

In general, the analytical results for supplies located in United States waters show similar characteristics in that the median and average values indicated a moderate pollution, whereas the maximum or peak values were indicative of heavy pollution. These characteristics exist due to the precarious locations of the river intakes near the edge of the normal pollution zone and of the Western New York Water Company's intake near the dumping grounds in Lake Erie. During periods of unusual flow this pollution zone widens, and the intakes are thus subjected to sporadic slugs of heavy pollution. For instance, maximum coliform M.P.N. values of, or greater than, 11,000 per 100 ml. were found at the Lake Erie intake of the Western New York Water Company, at the Tonawandas, and at the Niagara Falls No. 1 plant. Similarly, maximum phenols as high as 80 p.p.b. were found at these plants. These peak values are reflected in the maximum chlorine demand results which range up to 1.1 p.p.m. The wide and rather rapid changes in the character and intensity of polluting substances in the raw water have adversely influenced the purification problem. A sudden increase in pollution of the raw water results in a similarly sudden increase of the chlorine required for disinfection. The erratic chlorine demands experienced at these supplies are a continual hazard to public health. For these reasons, the New York State Department of Health has recommended that new water supply intakes be located in the waters of the West Channel.

The analytical results for the other two United States supplies do not show the same widely fluctuating quality. The intake for the City of Buffalo is located at the Niagara River inlet near the International Boundary where the raw water is not usually affected by sewage or industrial waste pollution. Plant records for 1949 indicate that the quality of the *raw* water meets the U. S. Public Health Service bacteriological requirements for a *treated* water. In contrast, the Niagara Falls No. 2 plant has a shore intake which is subjected to highly polluted water at all times. The M.P.N. coliform values had a median of 3,900 and a maximum of 110,000 per 100 ml., while phenols averaged 31.5 p.p.b. with a maximum of 80 p.p.b.

The supplies located along the Canadian side of the upper river are of uniformly good sanitary quality. The Town of Niagara supply near the mouth of the lower river, however, is markedly affected by pollution. The coliform and phenol results indicate that the operation of this treatment plant is continually handicapped by substantial pollution.

The operating records of the United States plants were reviewed in order to ascertain the changes taking place in the raw water quality over a more extended period. The proper disinfection of the supplies affected by sporadic pollution has been a continuous problem, requiring the rate of chlorine application to be varied in accordance with the degree of the pollution. Water plant records for the last ten years show that on no occasion was a treated water unsafe for human consumption. Notwithstanding, there have been occasions when water plants were unable to cope with rapid and extensive changes in chlorine demand. Such an occurrence in 1933 resulted in an outbreak of water-borne disease at Niagara Falls, New York, affecting approximately ten thousand people.

In addition to the difficulty of disinfection, the records show that taste and odor control has been a major problem in these same waters during the past 20 years. Little success was obtained in this control until the introduction in 1943 of chlorine dioxide treatment, which is now practiced at considerable additional expense at all the United States plants in this Section with the exception of that of Buffalo. While this has markedly reduced the problem, occasional complaints are still received.

TABLE N-22—SUMMARY OF ANALYTICAL RESULTS FOR MUNICIPAL INTAKE SAMPLES

International Joint Commission Field Data—1948-1949

Municipal Supply	Mileage Index		Coliforms M.P.N. per 100 ml.	Chlorides ppb	Phenols ppm	Amm. as N_3 ppm	Chlorine Demand ppm	D.O. ppm	B.O.D. 5 day ppm	Turbidity ppm	pH	Alkalinity ppm	Total Iron ppm
Western New York Water Company, New York	Range 2E, 4,425 feet from shore	Median	75	......	......	......	......	......	......	......	......	......	......
		Average	......	20.8	3.4	0.02	0.45	......	0.71	13.7	7.8	93	0.50
		Maximum	>11,000	25	26	0.22	0.70	......	3.4	47	8.4	99	1.2
		Minimum	<3.0	18	0	0	0.22	......	0.1	4	7.5	87	0.1
		No. of Samples	150	24	25	23	23	......	21	24	24	24	16
City of Buffalo, New York	Ni-37.7	Median	3.6	......	......	......	......	......	......	......	......	......	......
		Average	......	21	4	0.02	0.43	......	0.37	11.7	7.8	96	......
		Maximum	460	25	45	0.18	0.73	......	1.0	28	8.3	102	......
		Minimum	<3.0	18	0	0	0.23	......	0.1	4	7.3	91	......
		No. of Samples	78	24	26	23	23	......	22	25	25	24	......
Town of Fort Erie, Ontario (Upper Plant)	Ni-33.2	Median	3.6	......	......	......	......	......	......	......	......	......	......
		Average	......	20	Trace	......	......	12.9	0.5	11	8.2	90	......
		Maximum	15	21	Trace	......	......	......	1.0	26	8.4	94	......
		Minimum	3.6	18	0	......	......	......	0.0	1	7.9	86	......
		No. of Samples	3	3	3	......	......	1	2	3	3	3	......
Town of Fort Erie, Ontario (Lower Plant)	Ni-31.4	Median	2.0	......	......	......	......	......	......	......	......	......	......
		Average	......	19	0	......	......	13.3	0.9	16	8.1	94	......
		Maximum	43	21	Trace	......	......	13.8	1.5	28	8.4	100	......
		Minimum	2.0	17	0	......	......	12.8	0.1	1	7.9	88	......
		No. of Samples	5	5	4	......	......	3	4	5	5	5	......
City of Tonawanda, New York	Ni-26.2	Median	150	......	......	......	......	......	......	......	......	......	......
		Average	......	20.3	5.6	0.01	0.42	10.7	0.66	13.4	7.8	95	......
		Maximum	11,000	23	80	0.16	0.80	......	1.4	55	8.3	102	......
		Minimum	<3.0	17	0	0	0.18	......	0.1	1	7.4	90	......
		No. of Samples	96	31	31	31	30	1	28	32	31	31	......
City of North Tonawanda, New York	Ni-25.9	Median	230	......	......	......	......	......	......	......	......	......	......
		Average	......	20.4	2.4	0.01	0.46	9.1	0.6	9.4	7.8	95	......
		Maximum	4,600	24	16	0.12	0.78	......	5.8	28	8.3	100	......
		Minimum	3.6	18	0	0	0.23	......	0.1	2	7.4	90	......
		No. of Samples	90	29	30	29	29	1	25	30	30	28	......
City of Niagara Falls, New York (Plant No. 1)	Ni-18.7	Median	930	......	......	......	......	......	......	......	......	......	......
		Average	......	20.4	7.1	0.01	0.47	......	0.57	11.8	7.7	94	......
		Maximum	11,000	23	35	0.04	0.70	......	1.1	38	8.0	98	......
		Minimum	<3.0	17	0	0	0.18	......	0.2	2	7.3	89	......
		No. of Samples	54	14	16	16	15	......	15	15	16	14	......
City of Niagara Falls, Ontario	Ni-16.6	Median	93	......	......	......	......	......	......	......	......	......	......
		Average	......	20	0	0.04	......	13.1	1.1	17	8.0	92	......
		Maximum	2,400	22	4	......	......	14.0	1.9	31	8.3	98	......
		Minimum	3.6	18	0	......	......	11.4	0.1	1	7.9	88	......
		No. of Samples	11	11	10	1	......	9	7	11	11	11	......
City of Niagara Falls, New York (Plant No. 2)	Ni-16.4	Median	3,900	......	......	......	......	......	......	......	......	......	......
		Average	......	21.2	31.5	0.34	0.55	4.6	1.4	15.4	7.6	93	......
		Maximum	110,000	24	80	0.12	1.10	8.9	2.7	39	8.0	99	......
		Minimum	230	17	Trace	0	0.27	0.3	0.5	2	7.3	79	......
		No. of Samples	79	26	26	24	26	2	24	26	24	26	......
Town of Niagara, Ontario	Ni-1.9	Median	460	......	......	......	......	......	......	......	......	......	......
		Average	......	22	3	1.6	......	15.6	1.9	20	8.0	92	......
		Maximum	2,400	28	12	......	......	17.8	3.5	35	8.2	98	......
		Minimum	79	17	0	......	......	13.1	0.5	6	7.9	82	......
		No. of Samples	13	13	11	1	......	12	8	12	12	13	......

Municipal Sewage Treatment Plants

Special studies of the Buffalo and the Niagara Falls, New York, sewage treatment plants were conducted by the United States field staff during this investigation. The importance of these plants is apparent in view of the fact that the Buffalo plant serves some 70% of the population along the boundary waters, and the Niagara Falls plant over 10%. The study of the two plants showed in part the quantity and characteristics of the sewage plant effluents, and the efficiencies of treatment as denoted by the reduction in biochemical oxygen demand, suspended solids, and coliform densities. A special study was also made at the Niagara Falls plant to determine the toxicity of the effluent to fish life.

The survey of the Buffalo plant was conducted during a six-day period in May 1949. The plant provides primary treatment with chlorination of the effluent. Dry weather flow is about 113 M.G.D. (U.S.). Based on median M.P.N. coliform values, the effluent contained 43,000 per 100 ml., a reduction of 99% of that in the plant influent. The effluent B.O.D. was 154 p.p.m., representing a reduction of about 18%. The suspended solids concentration in the effluent was reduced about 47% to 104 p.p.m. The phenol content of the plant discharge averaged 77 p.p.b., and the chlorine demand 4.8 p.p.m.

The Niagara Falls treatment works survey was made during a six-day period in January 1949, and was followed by an additional bacteriological study in May 1949. This plant provides grit removal and fine screening, and chlorination during the summer months. The influent flow, which is composed of about 90% industrial wastes, averaged 85 M.G.D. (U.S.) during the survey period. The median M.P.N. coliform values per 100 ml. in the effluent were 90,000 during the January survey and 69,000 during the May survey. The treatment produced a reduction of 90% in coliform content when chlorination was practiced. Suspended solids in the effluent measured 425 p.p.m., a reduction of about 8% from that in the plant influent. The B.O.D. of the effluent was 73 p.p.m., representing a reduction of about 6%. The concentration of phenol averaged 362 p.p.b. and chlorine demand of 14.8 p.p.m.

A special bio-assay study was conducted by the New York State Conservation Department in January and February 1949 on the effluent from the Niagara Falls, New York, sewage treatment plant. The fish used in these experiments were *Notropis atherinoides,* the common "shiner" of the Niagara River. The maximum concentration of the waste used was a 10% dilution. The results of this study showed that the 10% dilution of the effluent had no toxic effect on the fish. Toxicity determinations with concentrations higher than 10% would not have been significant because of the high dilution available in the Niagara River.

Fish and Wildfowl

Some seventeen fish kills have been reported in the Lake Erie-Lake Ontario Section during the past 15 years. Three of these kills occurred during November and December of 1937 in the Buffalo harbor area, and were reported by the Buffalo Sewer Authority. The remaining fourteen fish kills occurred between 1943 and 1949 in the Buffalo harbor area and in the upper Niagara River. These latter kills have been investigated and reported by the New York State Conservation Department.

While the relative severity of each of the kills has not been estimated, the causative toxic agent for most of them has been determined. Cyanides are implicated as causing seven of the kills with phenols a contributory factor in two of these cases. A lethal dose of chlorine presumably was the cause of two of the kills, while large concentrations of copper and iron salts possibly caused four other kills. The toxic materials causing the four remaining kills, which include the three in 1937, could not be isolated. A large proportion of the fish destroyed have been minnows, particularly the "lake shiner". However, pike, bass, sunfish, and crayfish have been destroyed in lesser numbers.

The sources of the polluting substances causing these kills have been identified in several instances. Wastes discharged from the industries located on the Buffalo River and in the harbor area have presumably caused ten fish kills in that area. The most frequent toxic agents in these cases have been cyanides and copper and iron salts. In the Tonawanda area six kills have occurred in the Niagara River as follows: an automotive manufacturing company causing three kills due to cyanides, a company employing metal plating operations causing another kill due to cyanides, and a paper company plant apparently causing two kills due to chlorine discharges. The last reported kill occurred in the Niagara River at Niagara Falls, New York, but the causative factors were not determined.

Since the Niagara River is an important gathering point for migratory wildfowl, any pollution causing damage to the fowl is of economic importance. Many birds are killed going over the Falls during a fog or as a result of oil pollution. The heaviest mortality occurs during the period from early November to May. A major kill occurred during the 1948-49 season when a total of about 700 birds was swept over the Falls. Of this number it is estimated that 275 died as a direct result of oil pollution. This information is revealed from autopsies made by the Ontario Department of Lands and Forests on birds collected in the Maid of the Mist pool. The effect of oil on fowl is to destroy the buoyant effect of the protecting plumages, causing over-exposure to the icy waters. The bird is rendered helpless by a floating layer of oil.

While the effects of pollution on the feeding material of wildfowl has not been fully determined, it is believed to play an important role in the physical condition of the birds.

Effect of Plankton on Water Supplies

A special study was undertaken by the United States field staff in the fall of 1948 to determine if plankton organisms were the cause of certain taste and odor problems encountered in water supplies taken from the Niagara River. It was also desired to learn if the plankton found in the river came from Lake Erie or developed in creek mouths and quiet areas along the shore or in the polluted areas of the river itself.

The effect of pollution on plankton in the Niagara River was not clearly shown. The rate of flow in the river is so high that there is not sufficient time for plankton to attain any significant increase in number while in the river. The tributaries have small volumes of flow in comparison to that of the Niagara River. There was no evidence that significant numbers of taste producing plankton in the tributaries were carried into the Niagara River and, consequently, into the water supplies.

Diatoms were the predominant organisms in all samples including those taken from Lake Erie and Lake Ontario. The most common and characteristic among this group were *Asterionella formosa*, *Tabellaria fenestrata*, and *Fragilaria crotonensis*. These are true plankton which are not found attached to objects or the bottom of the stream. None of the diatoms was found in concentrations sufficient to produce taste in water supplies.

A few speciments of *Synura uvella* and *Uroglenopsis americana* (class Chrysophyceae) were found in the quiescent waters of Lake Erie, Lake Ontario, and in a swampy area at the downstream end of Grand Island. These organisms are notorious taste-producers but do not survive in swift water. However, the volatile taste-producing oils from disintegrating cells may, under proper conditions, cause tastes in water supplies. Therefore, their presence in Lake Erie is a potential taste and odor hazard to all water supplies along the Niagara River. Other algae were found in some of the samples taken above the water intakes but their concentrations were never high enough to produce taste.

A heavy concentration of the green algae *Cladophora sp.* was found in the East Channel above the Niagara Falls, New York, water intakes. While this organism probably does not produce taste independently, it may, in conjunction with certain organic wastes in water, produce objectionable taste. This aspect should be studied further. Cladophora may also be responsible for the periodic clogging of filters at water plants.

Taste and Odor Study—Buffalo River

A special study of tastes and odors of the Buffalo River water was conducted by the United States field staff in April 1949. The preliminary work included taking samples at the mouth of the river at its confluence with Buffalo Harbor and the Niagara River. Further studies were made at ranges 3.5 miles (Range NiBu-41.3) and 5.1 miles (Range NiBu-42.9) upstream from the mouth of the river.

The study showed that the Buffalo River at its confluence with the Niagara River contains definite taste and odor producing substances. Daily phenol analyses indicated that the river is subjected to slugs of phenolic type wastes. All samples at this location had a predominantly medicinal or iodoform taste. Since the tastes were more pronounced when the phenol content of the river was high, it may be assumed that at least part of the disagreeable tastes were due to phenolic type wastes.

Samples taken daily at Range NiBu-42.9 presented an odor that was described as petroleum, gasoline or kerosene, and which was not affected by chlorination. It was found that breakpoint chlorination curves followed a rather regular pattern with corresponding relationships in the taste dilution curves. It was not found, however, that a definite relationship existed between the threshold taste and the phenol content of the samples.

The odor of the samples from Range NiBu-41.3 was described as the same as from Range NiBu-42.9, although a faint odor of nitrobenzene was detected when the sample was heated. Breakpoint chlorination curves did not exhibit the same characteristics as those from Range NiBu-42.9, but displayed a chlorine absorption pattern followed by a sharp rise in chlorine residual.

Chapter N-IX

DISCUSSION OF FINDINGS AND REMEDIAL MEASURES

"When there is trouble there is need for someone to act as well as advise."

—Aesop.

Data presented in this report show the results of the investigation of pollution in the Lake Erie-Lake Ontario Section of the boundary waters. They indicate, in accordance with the terms of reference to the Commission, the extent, nature and sources of pollution, and in what localities such pollution occurs. The Board has examined and evaluated these various data. From this analysis certain conclusions have been reached, and remedial measures have been determined. The findings and conclusions are discussed herewith.

Canada and the United States jointly possess an unparalleled natural resource in the boundary waters. They constitute the largest body of fresh water in the world and are subject to a multiplicity of uses. Because they vitally affect the health, economy and recreation of both countries it is essential that the waters be so safeguarded from pollution that their use will be in the highest public interests. The importance attached to maintaining these waters in an unpolluted state is evident in the action taken by the two governments, on two separate occasions, in requesting that the International Joint Commission make an investigation of pollution.

The 1913 Investigation

The pollution problem in 1913 was materially different from that of today. The earlier investigation was concerned solely with bacterial pollution from domestic sewage. The industrial processes then in use did not discharge waste products in sufficient quantities to affect seriously the conditions of the waters.

As noted in chapter N-VIII certain areas of the Niagara River were found seriously polluted in 1913. Except for two septic tank-contact bed treatment units at Lackawanna, New York, and a third septic tank unit at Bridgeburg, Ontario (now the Town of Fort Erie), no sewage treatment installations were then in operation. Thus the raw sewage from nearly 540,000 people was discharged directly through many outlets to these boundary waters and their tributaries. Garbage and other refuse were also dumped into the Niagara River by the City of Niagara Falls, New York. All municipalities obtained their drinking water supplies from the river above their own immediate sewer outfalls. Several of these communities used the water untreated, while others used chlorination as the only protection against water-borne diseases. The two Niagara Falls, New York, supplies were the only ones receiving filtration.

The International Joint Commission, following the 1913 investigation, recommended to the two governments that, for the boundary waters as a whole,

> "It is feasible and practicable, without imposing an unreasonable burden upon the offending communities, to prevent or remedy pollution, both in the case of boundary waters and waters crossing the boundary.
>
> "(a) In the case of city sewage, this can best be accomplished by the installation of suitable collecting and treatment works, the latter having special reference to the removal of bacteria and matters in suspension.
>
> "(b) In the case of vessel sewage, a feasible and inexpensive remedy lies in the employment of recognized methods of disinfection before it is discharged. In the case of water ballast suitable rules and regulations should be prescribed with a view of protecting the water intakes.
>
> "(c) The discharge of garbage and sawmill waste into boundary waters should be prohibited, and industrial and other wastes, which are causing appreciable injury, should be discharged subject to such restrictions as may be prescribed."

Changes in Period 1913-1949

The pollution problem has been affected by many changes which have taken place in the period from 1913 to 1949. The large increases in population and industrial activities have contributed adversely to the problem. The construction of treatment works for both water and sewage has tended to partially remedy the situation. Continued progress in the sciences of water treatment and of domestic and industrial wastes treatment has provided methods for a more effective solution to this problem.

Comparative populations for the urban areas situated along the boundary waters in 1913 and 1949 are summarized in table N-23. Nearly a twofold increase in population, from 540,000 to 915,000 persons, occurred during this period. The

TABLE N-23—POPULATIONS SITUATED ON BOUNDARY WATERS, 1913 AND 1949

Area	1913			1949		
	Canada	United States	Total	Canada	United States	Total
Lake Erie	....	15,400	15,400	1,300	38,400	39,700
Upper Niagara River	3,800	471,200	475,000	7,500	698,900	706,400
Lower Niagara River	11,000	36,700	47,700	56,600	107,000	163,600
Lake Ontario	1,300	300	1,600	1,900	1,500	3,400
Total	16,100	523,600	539,700	67,300	845,800	913,100

rapid growths of the cities of Buffalo and Niagara Falls, New York, have been primarily responsible for this increase.

Although the pollution resulting from industrial wastes was of little or no concern in 1913, it is today a major problem. Vast expansion in industrial activities, particularly along the United States side of the upper Niagara River, has created large volumes and varieties of wastes.

The increasing pollution problem during the 36-year period since 1913 has compelled municipalities to construct sanitary works for water supply protection. All municipalities, with the exception of Fort Erie located near the Niagara River inlet, are using filtered water from the river. Chlorination has been utilized for the disinfection of all municipal supplies. Installations for the treatment of domestic wastes have not kept pace with the extension of sewer services and the treatment of water supplies, but definite progress has been made. The City of Buffalo has installed interceptors and primary treatment facilities serving some 600,000 persons. Eleven other sewage treatment plants have been built in New York at the following places: the cities of Niagara Falls, Lackawanna, and Tonawanda; the villages of Blasdell and Youngstown; the hamlets of Wanakah, Mt. Vernon, and Woodlawn; and the towns (townships) of Grand Island and Tonawanda. On the Canadian side, one plant has been built at Crystal Beach Village, and septic tank installations have been provided at Fort Erie Town, Chippawa Town, and Stamford Township. These plants now serve a total of about 778,000 persons with primary treatment only, and an additional 37,000 persons with secondary treatment. Much of the work on the United States side was financed with Federal aid during the period 1933 to 1940.

Sanitary science has made important contributions toward the solution of pollution problems in this same period. In 1913, the sciences of water purification and sewage treatment were in their initial stages of development. Modern methods of water treatment have become established with widespread usage since that time. Corresponding advances in sewage treatment methods have made possible the adoption of processes capable of producing an effluent of a high degree of purity. The science of industrial waste treatment, while given little thought in 1913, has provided new and improved processes for waste disposal resulting in increased efficiencies for certain industries. However, additional research is needed before similar advances can be attained in the treatment of many of the other industrial wastes.

Extent of Pollution in 1948-1949

Pollution was found in numerous localities and originating from many sources during the 1949 investigation. The analytical data, resulting from bacteriological, chemical, and physical examinations, are a measure of the extent and effects of various pollutants on these waters used for the purposes already enumerated. The kinds, degree, and locations of pollution are set forth in detail in the two previous chapters. The findings are reviewed and discussed herewith as to their effects on these waters and as related to the questions contained in the terms of the reference.

In the treaty of 1909 between the two countries it was agreed that the waters on either side of the boundary should not be polluted to the injury of health or property on the other side. The first question asked in the present reference to the Commission concerns the transboundary aspect of the pollution problem.

Transboundary Effects

The data and information presented in chapter N-VIII have shown clearly that there is a transboundary crossing, both of currents and pollution from either side to the other. This crossing has been demonstrated especially in the lower Niagara River and to a lesser extent in Lake Erie, upper Niagara River, and Lake Ontario. Since waste discharges tend to diffuse and become diluted with the receiving waters or other wastes downstream, it is difficult to trace a specific effluent over the distance required to dissipate its potency. Transboundary currents are largely influenced by such factors as heavy stream flows, ice stoppages, and seiches caused by winds and other varying meteorological conditions. Under these circumstances it is not feasible to state, in exact terms, the amount of pollution which crosses from either side to the other.

Injury to Health

The danger to health in the use of these waters is measured most readily by the coliform determinations, although constituents of a chemical nature are also of significant importance. Major uses of these waters include domestic and industrial water supply, power, navigation, bathing and recreation. Many of these uses are closely allied to public health and are injuriously affected by the discharge of bacterial and chemical pollutants.

Limits of pollution beyond which a health menace may exist are not universally accepted. Several standards have been formulated from time to time to apply to specific areas and requirements. In the final report on the 1913 investigation the Commission stated that "the standard of purification required of these communities should be such that the streams after receiving their treated sewage would have a mean annual cross-sectional average of *B. coli* not exceeding 500 per 100 cubic centimeters." A more recent standard for raw water, acceptable for treatment and use as a public water supply, is that recommended by the U. S. Public Health Service in 1946. In this recommendation, water which has an average monthly coliform content of not more than 50 per 100 ml. is acceptable for treatment by simple chlorination alone. Raw water having an average monthly coliform content of not more than 5,000 per 100 ml., and exceeding this number in not more than 20% of the samples examined in any one month, is acceptable for treatment by complete rapid sand filtration and continuous postchlorination. In cases where the coliform bacteria exceed 5,000 per 100 ml. in more than 20% of the samples examined during any one month, and do not exceed 20,000 per 100 ml. in more than 5% of the samples examined during any one month, the waters shall be acceptable when given auxiliary treatment in addition to complete rapid sand filtration and continuous postchlorination. Waters containing coliform bacteria in excess of the above figures are considered unsuitable for use as a source of drinking water supply unless brought into conformance by means of prolonged preliminary storage or some other satisfactory measure. It should be borne in mind that these standards are guides which should be interpreted through the exercise of administrative and technical judgment in the light of specific local conditions.

Since practically all the municipalities in the Lake Erie-Lake Ontario Section obtain their water supplies from the boundary waters, pollution by sewage may affect the entire population if these supplies are not properly purified. Although there have been no typhoid fever outbreaks attributable to public water supplies along the Niagara Frontier in recent years, the effects of water pollution have been manifested in other ways. Advances in water purification in the last 30 years have done much to reduce the menace of water-borne typhoid fever, but sewage contaminated waters can result in outbreaks of gastroenteritis and dysentery. Such an occurrence at Niagara Falls, New York, in 1933 involved approximately 10,000 cases of gastroenteritis. This incident was traced to the municipal water supply which was both filtered and chlorinated. It may be concluded that all sewage pollution must be considered as a potential health hazard.

The relation of coliform pollution in these waters to the standards for public water supplies recommended by the U. S. Public Health Service is a measure of the potential hazard to public health. It was shown in chapter N-VIII that the major pollution is generally confined within a zone along the United States shore of Lake Erie and along the easterly shore of the upper Niagara River. A lesser degree of pollution exists in the lower river and within an area in Lake Ontario at the river outlet. It was also shown that certain of the municipal water supplies in Lake Erie and in the upper river are particularly affected by polluted water during abnormal stream flow conditions.

In the main body of Lake Erie, the coliform values are within the limits recommended for a water supply protected by chlorination. The supplies of the City of Buffalo and the Town of Fort Erie are using this high quality water although located in the Niagara River inlet. The water along the United States shore, however, is considerably polluted, particularly in the Buffalo harbor area and near the mouths of tributaries. The water in several localities along shore would be considered unsuitable as a drinking supply source. The Western New York Water Company's supply, taken some distance offshore, is considered acceptable from a bacteriological standpoint, although it is at times affected by moderate sewage pollution.

The upper Niagara River receives the heaviest concentration of coliform organisms in the Lake Erie-Lake Ontario Section. As a consequence the quality of the water at many places is unsuitable as a source for potable water supply even when treated by modern purification methods. The westerly portion, including the West Channel, is for the most part acceptable from a bacteriological standpoint if chlorination is provided. The intakes for Tonawanda, North Tonawanda, Lockport, and Niagara Falls No. 1 plant are precariously located in East Channel waters normally beyond the zone of marked pollution but frequently subjected to sporadic heavy pollutional loads. Under these conditions, it is difficult to assure a safe water at all times since rapid changes in the chlorine demand of the raw water may not always be detected, with the result that some polluted water may pass through the treatment plant before adjustments can be made. The Niagara Falls No. 2 plant is supplied from a shore intake located in the zone of heavy pollution. The quality of this supply demands careful and sustained treatment to render it safe for drinking purposes. Plans have been formulated for the abandonment of this supply.

The coliform content of the lower Niagara River is fairly uniform and indicates a quality of water which is acceptable as a source for drinking water if filtration and chlorination, and possibly auxiliary treatment, are provided. The Town of Niagara, Ontario, with an intake near the river outlet, is the only municipal supply taken from the lower river.

There are no water supplies taken from the Lake Ontario area adjacent to the Niagara River. The water varies in quality, being similar to that of the lower river near its outlet and approaching the purity of the main body of Lake Ontario some 10 miles distant from the river outlet.

The presence of sewage pollution in bathing areas constitutes a health hazard. Public bathing facilities are located on the Canadian side of Lake Erie and at the upstream end of Grand Island. Elsewhere, bathing is not extensive as pollution had tended to interfere with the development of suitable areas. There is no statistical evidence to indicate that public health has been injured by pollution of bathing beaches in this section.

Injury to Property

The discharge of wastes into the boundary waters has interfered with the enjoyment of property rights and has caused injury to property along these waters. Economic losses have been reflected by the higher costs of water purification and in physical destruction or damage to wildlife and watercraft.

The higher costs of water purification in this area can be attributed to pollution by both sewage and industrial wastes. Bacterial pollution has added directly to the cost because more complete treatment is required. Industrial wastes containing taste and odor producing substances, particularly phenols, have created costly control problems in nearly all the municipal supplies. The many problems accompanying the purification of water supplies from intakes located in these polluted waters is prompting the location or extension of the intakes into cleaner water. Such relocation is costly, as evidenced by the $775,000 being spent by Niagara Falls, New York, in extending their No. 1 plant intake into the West Channel. The New York State Department of Health recommends that municipal intakes be located in the better quality water of the West Channel rather than in the waters of the nearer East Channel.

The physical damage imposed by pollution is difficult to evaluate, but nevertheless, is of vital importance. The destruction of both fish and wildfowl, as discussed in chapter N-VIII is of considerable significance. Industrial wastes containing cyanides, phenols, chlorine, and copper and iron salts have been implicated in causing many of the fish kills in the upper river. Oil pollution has at times caused widespread destruction of birds in these waters. Such situations, if continued, would do much to interfere with normal sports activities, which are an important asset to any watercourse. Wastes containing oils, greases, and tars coat the hulls of boats and docks and may constitute a potential fire hazard.

Aside from these evidences of property damage, mention should be made of the aesthetic value accorded to the Niagara River. The scenic resources afforded by both the Falls and the Niagara River are of considerable importance to the economics of the Niagara Frontier area. The promiscuous discharge of such deleterious materials as refuse, oils, or other obnoxious wastes would greatly detract from the appearance of these boundary waters.

Sources of Pollution

Pollution in these waters is principally due to the disposal of domestic sewage and industrial wastes. These wastes are discharged either through municipal sewer systems or through separate industrial outlets to the boundary waters and their tributaries. Wastes are discharged throughout the entire section of these waters, although there are several areas in which the primary sources of pollution are concentrated.

Sources of Domestic Wastes

The municipalities chiefly contributing domestic sewage to the boundary waters are listed in table N-11 of chapter N-VII. All of the large municipalities in this section are sewered, and a majority have sewage treatment plants.

In Lake Erie the major sources of pollution are located along the United States side. The sewered population of 30,000 persons at Lackawanna, immediately south of Buffalo, constitutes about three-fourths of the total sewered population along Lake Erie. Several small villages located farther south along the lake shore and Crystal Beach Village on the Canadian side also discharge sewage into the lake area. The sewage from all these municipalities is subjected to some degree of treatment.

Along the upper Niagara River, the City of Buffalo, with about 600,000 persons, represents nearly 70% of the total sewered population in the Lake Erie-Lake Ontario Section. Nearly all of the city's sewage receives primary treatment, except for intermittent discharges of raw sewage during storm periods. A total of 50 storm water overflows discharge excess storm water which contains some raw sewage. The majority of these overflows discharge into the Buffalo River, the remainder discharging into the harbor area and the Niagara River. Other principal sources along the United States side of the upper river are in the Tonawanda area. The Town (township) of Tonawanda, immediately north of Buffalo, discharges treated sewage from a population of 36,000 persons into two small streams tributary to the East Channel. The City of Tonawanda, with a sewered population of 15,000, is provided with a primary treatment plant and three storm water overflows discharging to the East Channel. Raw sewage from the City of North Tonawanda with a sewered population of 27,000 enters the East Channel through five shore outfalls. The Town of Fort Erie with a population of 7,500 is the only municipality on the Canadian side disposing of sewage into the upper river.

Domestic sewage enters the lower Niagara River within the section of rapids extending some six miles downstream from the Falls. The City of Niagara Falls with a sewered population of about 105,000 persons is the only source of sewage on the United States side. The sewage is subjected to fine screening, supplemented by chlorination during the summer months, except for intermittent discharges from the city's eight overflow sewers. On the Canadian side, raw sewage from the City of Niagara Falls, with a population of 22,000 persons, is discharged into the river. The discharge from the H.E.P.C. power canal contains the domestic wastes from some 26,000 persons located upstream.

In the Lake Erie-Lake Ontario Section, the present survey showed a daily discharge of 228 million U. S. (190 Imp.) gallons of municipal wastes. About 210 million U. S. (175 Imp.) of this amount receives some degree of treatment. In many cases, however, this treatment is not adequate. With one exception, storm water overflows are not treated.

Sources of Industrial Wastes

Information on industrial waste discharges in the Lake Erie-Lake Ontario Section, showing distribution by areas, has been given in table N-15 in chapter N-VII. This table reveals that the heaviest concentrations are discharged along the United States shores of Lake Erie and the Niagara River, and along their tributaries. Little pollution was shown to occur along the Canadian shore of the Niagara River, with the exception of wastes reaching the Welland River and entering the lower Niagara River by way of the H. E. P. C. power canal. No industrial pollution enters Lake Ontario directly.

A total of about 500 million U. S. (420 Imp.) gallons of industrial wastes, or nearly twice that of the municipal wastes, is discharged daily. This volume includes condenser and cooling water as well as process wastes. Of this amount about 30% is discharged to Lake Erie on the United States side and 60% to the United States side of the Niagara River.

The daily discharge of the more significant polluting substances in these wastes was found to be: 6,340 pounds of phenol, 1,755 pounds of cyanides, 10,565 pounds of ammonium compounds, 1,890 U. S. (1,575 Imp.) gallons of oil, 757,130 pounds of suspended solids, and organic matter having a biochemical oxygen demand of over 96,000 pounds.

Sources of Other Wastes

In addition to municipal and industrial effluents, these waters receive wastes from dredging, navigation, and careless dumping of refuse. Reference has been made in chapter N-VII as to the nature and extent of these practices.

Dredged material from the Buffalo area is deposited in dumping grounds located in Lake Erie near the mouth of Smokes Creek, while material from the Niagara River is deposited near the downstream end of Grand Island. Substantial amounts of polluting substances are transferred in this way to normally clean waters.

Pollution contributed by vessels is most significant in the Buffalo harbor area. Many freight and several large passenger ships operate into the port of Buffalo. These contribute bacterial wastes in the form of sewage and refuse, and oil wastes found in bilge and ballast waters.

The widespread dumping of garbage or other refuse into these waters is not ordinarily practiced, although this did occur recently at the City of Niagara Falls, New York, over a period of several weeks until corrective measures were taken. Dumping of such material causes unsightly appearances.

Remedial Measures

It has been shown that serious pollution exists in the Lake Erie-Lake Ontario Section of the boundary waters. The terms of reference require information on measures necessary for remedying the situation. Such measures must raise the quality of the water to the point where they will be satisfactory for domestic and other uses.

Objectives for Boundary Waters Quality Control

Remedial measures involve the treatment or control of all sources of pollution reaching the boundary waters and their tributaries. Information acquired during the investigation enables the Technical Advisory Board to prepare "Objectives for Boundary Waters Quality Control."

The formulation of water quality objectives is essential for defining the remedial measures necessary for abating pollution. Objectives may be established in two ways: (1) through limitation of the quantity of deleterious substances allowed to enter the receiving streams, or (2) through limitation of these substances within the receiving waters. Whichever type of objective is used, the end result must be the same, namely, maintenance of the water in a condition suitable for all subsequent uses.

Objectives adopted for boundary waters quality control establish the ultimate aim of corrective measures. Such objectives must be outlined if stream pollution abatement is to be successful and impartial. Each water use requires a specific quality of water, and in the majority of cases, the uses of a watercourse are varied. Therefore, the complex interrelationships of these uses must be considered when establishing objectives. An effort has been made to adhere to these principles in the formulation of the following objectives:

OBJECTIVES FOR BOUNDARY WATERS QUALITY CONTROL

The term "boundary waters" as herein used shall include the waters defined in the amended reference to the International Joint Commission dated April 2, 1948, and is as follows:

> Niagara River from Lake Erie to Lake Ontario.

These objectives are for the boundary waters in general, and it is anticipated that in certain specific instances, influenced by local conditions, more stringent requirements may be found necessary.

General Objectives

All wastes, including sanitary sewage, storm water, and industrial effluents, shall be in such condition when discharged into any stream that they will not create conditions in the boundary waters which will adversely affect the use of these waters for the following purposes: source of domestic water supply or industrial water supply, navigation, fish and wildlife, bathing, recreation, agriculture and other riparian activities.

In general, adverse conditions are caused by:

(A) Excessive bacterial, physical or chemical contamination.

(B) Unnatural deposits in the stream, interfering with navigation, fish and wildlife, bathing, recreation, or destruction of aesthetic values.

(C) Toxic substances and materials imparting objectionable tastes and odors to waters used for domestic or industrial purposes.

(D) Floating materials, including oils, grease, garbage, sewage solids, or other refuse.

Specific Objectives

In more specific terms, adequate controls of pollution will necessitate the following objectives for:

(A) *Sanitary Sewage, Storm Water, and Wastes from Watercraft*

Sufficient treatment for adequate removal or reduction of solids, bacteria and chemical constituents which may interfere unreasonably with the use of these waters for the purposes afore-mentioned.

Adequate protection for these waters, except in certain specific instances influenced by local conditions, should be provided if the coliform M.P.N. median value does not exceed 2,400 per 100 ml. at any point in the waters following initial dilution.

(B) *Industrial Wastes*

(1) Chemical Wastes—Phenolic Type

Industrial waste effluents from phenolic hydrocarbon and other chemical plants will cause objectionable tastes or odors in drinking or industrial water supplies and may taint the flesh of fish.

Adequate protection should be provided for these waters if the concentration of phenol or phenolic equivalents does not exceed an average of 2 p.p.b. and a maximum of 5 p.p.b. at any point in these waters following initial dilution. This quality in the receiving waters will probably be attained if plant effluents are limited to 20 p.p.b. of phenol or phenolic equivalents.

Some of the industries producing phenolic wastes are: coke, synthetic resin, oil refining, petroleum cracking, tar, road oil, creosoting, wood distillation, and dye manufacturing plants.

(2) Chemical Wastes, other than Phenolic
Adequate protection should be provided if:

- (a) The pH of these waters following initial dilution is not less than 6.7 nor more than 8.5. This quality in the receiving waters will probably be attained if plant effluents are adjusted to a pH value within the range of 5.5 and 10.6.
- (b) The iron content of these waters following initial dilution does not exceed 0.3 p.p.m. This quality in the receiving waters will probably be attained if plant effluents are limited to 17 p.p.m. of iron in terms of Fe.
- (c) The odor-producing substances in the effluent are reduced to a point that following initial dilution with these waters the mixture does not have a threshold odor number in excess of 8 due to such added material.
- (d) Unnatural color and turbidity of the wastes are reduced to a point that these waters will not be offensive in appearance or otherwise unattractive for the afore-mentioned uses.
- (e) Oil and floating solids are reduced to a point such that they will not create fire hazards, coat hulls of water craft, injure fish or wildlife or their habitat, or will adversely affect public or private recreational development or other legitimate shore line developments or uses. Protection should be provided for these waters if plant effluents or storm water discharges from premises do not contain oils, as determined by extraction, in excess of 15 p.p.m., or a sufficient amount to create more than a faint irridescence.

Some of the industries producing chemical wastes other than phenolic are: oil wells and petroleum refineries, gasoline filling stations and bulk stations, styrene co-polymer, synthetic pharmaceutical, synthetic fibre, iron and steel, alkali chemical, rubber fabricating, dye manufacturing, and acid manufacturing plants.

(3) Highly Toxic Wastes
Adequate protection should be provided for these waters if substances highly toxic to human, fish, aquatic, or wildlife are eliminated or reduced to safe limits.
Some of the industries producing highly toxic wastes are: metal plating and finishing plants discharging cyanides, chromium or other toxic wastes; chemical and pharmaceutical plants and coke ovens. Wastes containing toxic concentrations of free halogens are included in this category.

(4) Deoxygenating Wastes
Adequate protection of these waters should result if sufficient treatment is provided for the substantial removal of solids, bacteria, chemical constituents and other substances capable of reducing the dissolved oxygen content of these waters unreasonably. Some of the industries producing these wastes are: tanneries, glue and gelatin plants, alcohol, including breweries and distilleries, wool scouring, pulp and paper, food processing plants such as meat packing and dairy plants, corn products, beet sugar, fish processing and dehydration plants.

Note: The methods of determination of the chemical constituents referred to in the preceding objectives are as given in "Analytical Methods for Boundary Waters Quality Control," as prepared by the Board of Technical Advisers. Bacterial determinations are to include the presumptive and confirmed tests for the coliform group of bacteria as given in "Standard Methods for the Examination of Water and Sewage," 9th Edition.

Hearings Before the Commission

Public hearings for municipalities, industries, and all other interested parties were held by the International Joint Commission in Buffalo on November 15 and 16, and December 13, 14, and 15, 1949, and at Niagara Falls, Ontario, on November 17, 1949. The purpose of these hearings was to obtain information on waste treatment processes now in use or proposed, cost estimates of remedial measures, time required to carry out these measures, and comments on the application of the objectives to specific wastes. The principal points developed at the hearings were as follows:

- (a) The evidence brought out at the hearings indicates that the pollution affecting municipal water supplies is due both to industrial wastes and domestic sewage.
- (b) Pollution in boundary waters has resulted in

the serious destruction of wildfowl, fish and other aquatic life.

(c) In the past, pollution from the Niagara River has extended eastward along the southern shore of Lake Ontario affecting water intakes. However, no such difficulty has been recorded in the past 10 years.

(d) Plans of industries for dealing with their waste problems indicate that most of the industries take their responsibilities seriously keeping deleterious wastes out of boundary waters, and are making plans or have completed works for treatment of their wastes.

(e) Plans for collecting and treating municipal wastes as well as extending existing facilities are in preparation by certain municipalities.

(f) Municipalities are relatively inactive at the present time insofar as the construction of works for treating sewage is concerned. Boundary waters are being denied the benefits of municipal pollution control by the limited ability of some communities to finance treatment works.

(g) The need for promptly providing funds to construct necessary municipal sewage treatment works has been shown.

(h) The people living near the boundary waters have been thwarted in their efforts to make recreational use of boundary waters because of pollution.

(i) To protect recreational investments and to permit present and future industries to have access to reasonably clean waters for industrial purposes, it is necessary to curb the tendency toward increased pollution of boundary waters and to eliminate much of the pollution now being added to these waters.

(j) Municipalities and industries represented at the hearings were in general agreement with the "Objectives for Boundary Waters Quality Control."

(k) Evidence was presented that the International Joint Commission should maintain a continuing interest in the condition of these boundary waters, and that an effective way should be found in which to exercise such interest.

Pollution Control Program

It is apparent from the data presented in the foregoing that a comprehensive waste treatment program is required. Two methods for dealing with water pollution problems are commonly advocated. One viewpoint stresses the utilization of the stream for carrying away as much waste as it can tolerate without interfering too seriously with normal stream uses. The other would exclude all impurities from water courses. Between these conflicting views is a course which the Advisory Board feels will meet the situation. This course has been followed in developing the "Objectives for Boundary Waters Quality Control." No tolerance limit, whether for the effluent or for the stream, can be expected to remain fixed. It must change with changing conditions and each change should be in the public interest.

The large volume of water flowing between the United States and Canada should be regarded as a natural resource to be shared by both countries. It should not be wantonly destroyed by pollution, either from municipalities, from industries, or any other source. An intelligent policy of safeguarding these waters from gross pollution should be fostered and encouraged so that they will be used for the highest public good and not exploited by selfish interests.

The pollution problem must be considered not only on the basis of present-day conditions but also in terms of the future. Facilities for the treatment of municipal sewage must incorporate sufficient flexibility to permit ready expansion to satisfy future demands. Industrial waste disposal programs must not only provide adequate treatment for the present, but they must ensure that new industries or new industrial processes which may be established will not jeopardize the rights of users of these waters. Industry must continue to assume, in cooperation with other agencies, the research and planning required for satisfactory and efficient disposal of industrial wastes.

Disposal of Municipal Wastes

Since municipal sewage carries the organisms of diseases transmissible to humans, its disposal into the boundary waters creates a major problem. The heavy bacterial load placed on these waters is indicated by a sewage discharge totaling 228 million U. S. (190 Imp.) gallons per day. This flow represents a contributing population of nearly 900,000 persons. About 90% of the sewage receives some degree of treatment, but in practically all cases only primary treatment is utilized.

The coliform content of the boundary waters found during the present investigation showed a reduction from that found during the 1913 survey. In 1913 raw sewage from a population of nearly 540,000 persons was disposed of into these waters. In the final report of that investigation, it was recommended that the sewage be treated either by fine screening or sedimentation and, when necessary, by chemical disinfection in order to secure in the receiving waters a mean annual cross-sectional average *B. coli* of 500 per 100 cubic centimeters. Despite the fact that the population situated along the boundary waters has almost doubled since 1913, the construction of sewage treatment plants has resulted in a reduction in the over-all bacterial pollution.

Even though bacteriological conditions in these waters have improved during recent years, the present investigation reveals that further improvement is necessary. Primary treatment of sewage has been provided in a number of plants, but many municipalities discharge raw or inadequately treated sewage. It is obvious that, as a first step, effective primary treatment of sewage from all communities, by sedimentation and disinfection of the effluents, should be undertaken immediately.

It is the opinion of the Advisory Board that the question of a further degree of treatment will depend on a number of factors. Local conditions at any place on either side of the boundary may give emphasis to the need for more complete treatment. Major population growth, industrial expansion, or changes affecting the hydraulic regimen of the river may precipitate conditions in the future which will materially alter the requirements of treatment necessary to meet the objectives for boundary waters quality control. It is not possible to predict these situations now with any degree of accuracy. It is recognized that regardless of the extent of treatment of sewage and industrial wastes, municipalities along the upper river will find it preferable to extend their water intakes beyond the zone of stratification carrying these treated wastes. Treatment and points of disposal should be such to ensure against adversely affecting the water at these extended intakes or placing an undue loading on water plants in the lower river where the effects of stratification are lost in the more complete mixing and dilution across the width of the river.

Storm water overflows from combined sewers should be considered in conjunction with programs for treatment of sewage and industrial wastes. These storm flows may discharge large quantities of wastes in times of heavy run-off and thereby create adverse conditions. Generally effective protection can be ensured by the use of adequate retention in sedimentation tanks followed by disinfection, by storage in enlarged interceptor sewers, or by any other means.

Failure to provide adequate capacity, or the misuse, or the neglect of treatment facilities must be avoided. Inefficient operation of a plant or unwarranted bypassing of untreated or partially treated sewage must not be permitted.

The Board of Technical Advisers is of the opinion that reasonable stream sanitation consistent with the wide variety of uses of these waters, both present and future, will be maintained if the wastes are treated to a degree which will result in a median coliform M.P.N. value not exceeding 2,400 per 100 ml. at any point in the boundary waters following initial dilution of waste discharges. It will likewise be necessary to provide sufficient treatment of other substances, as defined in the objectives, which may injuriously affect the water.

Disposal of Industrial Wastes

The volume of industrial wastes discharged directly into these waters, exclusive of that carried in municipal sewers, is 500 million U. S. (420 Imp.) gallons per day, or twice that of municipal sewage. As shown in table N-15, chapter N-VII, large quantities of deleterious substances are carried in these wastes, seriously affecting the quality of the receiving waters and causing injury to health and property.

Industrial wastes, in contrast to domestic sewage, are so varied in composition that uniform treatment processes are not applicable. Each waste must be considered individually in the light of the deleterious substances present. Certain of these substances are of particular significance in these waters, and their limits of tolerance are included in the objectives for boundary waters quality control. The problem of industrial waste treatment must remain the responsibility of the industry involved.

One of the serious problems of industrial waste disposal is that of sudden or concentrated discharges, commonly known as "slugs" or "spills". These constitute the release of a volume of highly concentrated polluting material over a short period of time. Such discharges are intermittent, but their effects may extend for great distances and for prolonged periods. It is the obligation of industry to avoid slugs and spills. Retention tanks or lagoons should be provided where such conditions may occur, so that the discharge will be at a uniform rate.

Buffalo River Pollution Abatement Program

The slug-type releases from the Buffalo River and harbor area into the Niagara River are of even greater significance than the sudden discharges from individual industries. The hydraulic features of this highly industrialized area, as discussed in chapter N-IV, are such that pollutants become increasingly concentrated during periods of low flow in the Buffalo River and may subsequently be discharged as a slug during high river flows. Such slugs seriously affect the quality of the water in the Niagara River. Since operators of water purification plants are not aware of the approach of these slugs, some polluted water may pass through the water plant before treatment can be adjusted to produce a safe water.

The gross pollution of Buffalo River during low flow periods has created other problems. The concentration of pollutants in the river makes it unsuitable for an industrial supply. This situation prompted a comprehensive investigation and analyses of industrial wastes of five major industries located on the Buffalo River. The investigation was undertaken in 1946 jointly by the technical representatives of industry, the Buffalo Sewer Authority, and the state departments of health and conservation. A program for reduction of pollution was agreed upon. This provided for approximately 50% reduction of the organic pollution load (B. O. D.) then existing and the elimination of toxic and acid waste discharges from these industries. In addition and as a component part of the program, a plan known as the Lake Erie Cooling Water Project was agreed upon, which provides that these industries participate in pumping 120 to 180 M.G.D. (U.S.) of water from Lake Erie for industrial and cooling purposes. This would have the additional benefit of providing water to the Buffalo River at times of low flow. The benefits to the industries concerned may be summarized as follows: the project should provide cooler water and thereby more efficient cooling operations, eliminate the corrosion of cooling equipment and piping, eliminate the need for liming to neutralize acid wastes, eliminate the deposition of suspended solids in the plants, and provide approximately one-third of the oxygen demand of the industrial wastes. It should be noted that this diluting water will not reduce the pollution added to the Buffalo River, but by augmenting the low river flow it should reduce the concentration of pollutants in the river and thereby minimize the hazard of slug discharges to the Niagara River.

Disposal of Other Wastes

Other wastes originate chiefly from dredging, navigation, and refuse disposal. While these wastes are of secondary importance, they contribute to the pollution of these boundary waters.

Dredging operations transfer substantial amounts of polluting substances into normally clean waters. The dumping grounds for this material should be selected so as not to interfere with legitimate water uses, or result in the transboundary travel of the dumped material.

Vessels add pollution by their discharge of sewage, bilge water, and ballast water. Bacterial pollution can be corrected by the use of sewage retention tanks, accompanied by some form of disinfection, which tanks can then be emptied either to shore treatment facilities or overboard into nonrestricted areas. Oil pollution from bilge and ballast waters can be reduced by the installation of oil separators.

The disposal of garbage and other refuse into these waters would greatly detract from their scenic value. Boats should provide facilities for storing this material for subsequent disposal on land. Dumping from shore by municipalities or careless persons should be controlled by state or provincial, or local agencies.

Progress in Pollution Control

Much of the progress in the treatment of municipal wastes disposed into these waters was accomplished during the late 1930's. During that period, the cities of Buffalo, Tonawanda, and Niagara Falls, New York, constructed sewage treatment works at an expenditure of about $20,000,000. While no treatment plants have been constructed following 1940, several municipalities have been active since the war in preparing plans for the initiation of projects in the future.

Substantial progress in the control or elimination of industrial pollution has been accomplished during the 5-year period since termination of the war. Several factors have been responsible, such as availability of materials, stimulation by state and provincial authorities and interest of sportsmen's organizations, research on waste disposal methods, and the activities associated with this investigation. At the time of the hearings in 1949 it was estimated that industry had spent about $5,000,000 in the past five years and was contemplating expenditures totaling nearly $2,000,000 for further corrective measures.

Present Status of Municipal Waste Treatment

The present status of waste treatment programs for the New York municipalities situated along the boundary waters is as follows:

Municipality	*Present Status*
	Lake Erie Area
Town of Hamburg	
Wanakah Sewer District	Primary treatment with chlorination of effluent. No plans for plant expansion.
Mt. Vernon Sewer District	Primary treatment with chlorination of effluent. No plans for plant expansion
Woodlawn Sewer District	Primary and secondary treatment with chlorination of effluent. No plans for plant expansion.

Municipality	*Present Status*
Blasdell Village	Primary and secondary treatment without chlorination of effluent. Construction under way for a new treatment plant to provide primary and secondary treatment for sewage from new Bethlehem Steel Company plant, Ford Motor Company plant, and two subdivisions as well as Blasdell. Plant scheduled for completion December 1950.
Lackawanna City	Primary and secondary treatment with chlorination of effluent. Plans have been approved for additional sludge handling facilities, but construction delayed.
	Niagara River Area
Buffalo City	Primary Treatment with chlorination of effluent. Plans for enlarging certain units under consideration.
Town of Grand Island	
Sewer District No. 1	Primary treatment with chlorination of effluent. Plans for plant expansion under way.
Sewer District No. 2	Plans under way for a primary treatment plant with chlorination of effluent to serve another small portion of the town known as Sandy Beach.
Tonawanda City	Primary treatment with chlorination of effluent. No plans for plant expansion.
North Tonawanda City	No treatment. Construction plans for interceptors and primary treatment with chlorination of the effluent are approved. Construction will be over a five-year period.
Town of Tonawanda	
Sewer District No. 2	Primary treatment with chlorination of the effluent. No plans for expansion.
Sewer District No. 3	Primary and secondary treatment without chlorination of effluent. No plans for expansion.
Niagara Falls City	Fine screening plant, with chlorination of effluent during summer season. Studies under way to determine possibility of remodeling plant for sedimentation.
Lewiston Village	No municipal sewers. Plans for sewers and primary treatment approved, but construction not imminent.
	Lake Ontario Area
Youngstown Village	Primary treatment with chlorination of effluent. No plans for expansion.

In Ontario, the present status of the sewerage programs for the boundary municipalities is as follows:

	Lake Erie Area
Crystal Beach Village	Primary and secondary treatment with chlorination of the effluent. Plans under consideration to provide further primary treatment for peak summer loads.
	Niagara River Area
Fort Erie Town	Septic tank treatment without chlorination of effluent. Plans under consideration for treatment plant.
Chippawa Village	Septic tank treatment without chlorination of effluent. No plans for further treatment plant under consideration.
Niagara Falls City	No treatment. Plans for treatment plant under consideration.
Stamford Township	Septic tank treatment for half of sewage. No treatment for remainder. No plans for treatment under consideration.
Welland City	No treatment. Preliminary studies under consideration.
Queenston Village	No municipal sewers. No plans for sewers or treatment works.
Niagara Town	No treatment. No plans for treatment works.

Present Status of Industrial Waste Treatment

The status of industrial waste treatment on each side of the boundary is presented below. This status is indicated by key numbers as shown. Where an industry provides treatment prior to waste discharge to the municipal sewer system, the key number (3) precedes those key numbers that apply to the status of waste treatment provided by the industry.

(1) Control measures provided.
(2) Control measures provided. Adequacy not demonstrated.
(3) Municipal sewerage facilities utilized.
(4) Actual construction under way.
(5) Studies and plans under way.
(6) No progress indicated.

In New York, the status of the industries is as follows:

Industry	*Status*
Allegheny Ludlum Steel Corporation	
Sewage	(6)
Bethlehem Steel Company	
Acid waste	(5)
Cyanide waste	(1)
Oil waste	(5)
Phenol waste	(1)
Solids	(4)
Sewage	(6)
Carborundum Company	
Solids	(6)
Sewage	(3)
Chevrolet-Tonawanda, Division of General Motors Corporation	
Oil wastes	(5)
Sewage	(1)
Donner-Hanna Coke Corporation	
Cyanide waste	(6)
Phenol waste	(5)
Sewage	(3)
Dunlop Tire and Rubber Corporation	
Industrial waste	(1)
Sewage	(1)
E. I. du Pont de Nemours & Company, Inc. Electrochemicals Department	
Industrial waste	(1)
Sewage	(3)
E. I. du Pont de Nemours & Company, Inc. Rayon Division	
Industrial wastes	(2)
Sewage	(1)
Durez Plastics & Chemicals, Inc.	
Phenol wastes	(3), (2), and (5)
Sewage	(3)
Electro Metallurgical Division, Unit of Union Carbide & Carbon Corporation	
Solids	(2)
Sewage	(3)
Frontier Oil Refining Corporation	
Oil wastes	(2)
Sewage	(1)
General Chemical Division, Allied Chemical & Dye Corporation	
Acid wastes	(1)
Sewage	(3)
Hooker Electrochemical Company	
Industrial wastes	(3)
Sewage	(3)
International Paper Company, Niagara Falls Plant	
Industrial wastes	(2)
Sewage	(3)
International Paper Company, Tonawanda Plant	
Industrial wastes	(2)
Sewage	(6)
Iroquois Gas Corporation, Subsidiary of National Fuel Corporation, Bradley Street Plant	
Industrial wastes	(3) and (2)
Sewage	(3)
Iroquois Gas Corporation, Subsidiary of National Fuel Corporation, Mineral Springs Road Plant	
Industrial wastes	(3) and (6)
Sewage	(3)
Kimberly-Clark Corporation	
Industrial wastes	(3)
Sewage	(3)
Mathieson Chemical Corporation	
Industrial wastes	(3), (2), and (5)
Sewage	(3)
National Aniline Division, Allied Chemical & Dye Corporation	
Industrial wastes	(2) and (5)
Sewage	(3)
Niacet Chemicals Division, United States Vanadium Corporation, Unit of Union Carbide & Carbon Corporation	
Industrial wastes	(3)
Sewage	(3)
Niagara Alkali Company	
Industrial wastes	(3), (1), and (5)
Sewage	(3)
Oldbury Electro-Chemical Company	
Industrial wastes	(3) and (1)
Sewage	(3)
Republic Steel Corporation	
Acid wastes	(2)
Oil wastes	(5)
Solids	(2)
Sewage	(3)
Semet-Solvay Division, Allied Chemical & Dye Corporation	
Cyanide wastes	(6)

Industry	*Status*
Phenol wastes	(6)
Sewage	(2)
Socony-Vacuum Oil Company, Inc.	
Industrial wastes	(2) and (5)
Sewage	(3)
Spaulding Fibre Company, Inc.	
Phenol wastes	(5)
Sewage	(3)
Tonawanda Boxboards Division, Robert Gair Comany, Inc.	
Industrial wastes	(1)
Sewage	(3)
Van Raalte Company, Inc.	
Industrial wastes	(3)
Sewage	(3)
Wickwire Spencer Steel Division, Colorado Fuel & Iron Corporation	
Acid wastes	(1)
Oil wastes	(5)
Solids	(5)
Sewage	(1)

In Ontario, the present status of industrial waste treatment programs is summarized as follows:

Industry	*Status*
North American Cyanamid Limited, Welland Works	
Cyanide wastes	(2)
Ammonium wastes	(2)
Solids	(2)
North American Cyanamid Limited, Niagara Falls Plant	
Solids	(5)
Norton Company	
Solids	(3)
Canadian Carborundum Company	
Solids	(3)

Costs and Financing

The following cost estimates for remedial measures have been prepared in answer to the question in the reference. The municipal costs are given for primary treatment including the required intercepting sewers. For industries, the costs are estimated on the basis of compliance with the objectives for boundary waters quality control. The cost of the Lake Erie Cooling Water Project is also shown, inasmuch as it would substantially reduce heavy slugs of pollution in the Niagara River.

Costs for Municipalities (interceptors and primary treatment)	
United States side	$7,250,000
Canadian side	2,250,000
Total Municipal	$9,500,000

Costs for Industries		
United States side	$4,000,000	
Canadian side	100,000	
Total Industrial	$4,100,000	
Lake Erie Cooling Water Project	$5,500,000	
GRAND TOTAL		$19,100,000

A major difficulty in the solution of water pollution problems has been the reluctance of municipalities and industry to make funds available for this purpose. This may be due either to financial inability, lack of responsibility by the polluter, or indifference on the part of the public. Accordingly, it is important to consider methods of securing funds for the construction and operation of remedial works.

Remedial works for treating municipal wastes must be constructed through public funds. These may come from any of several sources such as cash reserves, short term loans or debentures, general obligation bonds, special assessment bonds, revenue bonds, government aid, or any combination of these. The annual payments on capital debts incurred by the municipalities for such works and for their operation may come from general taxation or some form of service charge. Since the sewage works are designed for the benefit of the entire community and are an obligation of the municipality, some municipal authorities favor paying part of the costs by general taxes. In order to apportion the remaining costs on the basis of benefits derived the practice of applying a service charge is gaining widespread use. These service charges are designated by several names such as sewer rates, sewage service rates, sewer rentals, and others. These rates have advantages which justify serious study by public officials confronted with the problem of financing municipal sewage treatment works.

It is a recognized fact that the correction of industrial waste pollution is the responsibility of the industry. Experience has demonstrated that in certain industries it is possible to reclaim from the wastes useful by-products which offset the cost of disposal, or to modify processes in an effort to reduce wastes. The treatment or control of these wastes, however, whether profitable or otherwise, must be regarded as a part of the cost of production.

Legislation on Pollution Control

Legislation applicable to water pollution control in this section of the boundary waters was reviewed in chapter N-V. It defines federal, state and provincial, and municipal responsibilities and jurisdictions.

Federal legislation in the United States centers about Public Law 845, passed in 1948, and known as the "Water Pollution Control Act." It was designed "to provide Federal technical services to State and interstate agencies and to industries, and financial aid to State and interstate agencies and to municipalities in the formulation and execution of their stream pollution abatement programs." There is also Federal legislation applicable to certain types of pollution entering harbors and other navigable waters.

In Canada there is no Federal legislation which is concerned with pollution of water per se. There are, however, certain statutes which indirectly deal with this problem, particularly as applied to navigation, fisheries and wildlife.

In the State of New York, pollution control is centered in Article VI of the Public Health Law. A Water Pollution Control Board, created by this new law, has full authority to deal with all types of pollution.

In the Province of Ontario legislation applicable to pollution control is contained in the Public Health Act and other enactments.

Municipalities are authorized to enact regulations or by-laws dealing with such local matters as control of pollution, restrictions on the use of sewers, setting sewer service rates, and financing.

The Continuing Program

It is recognized that the control of pollution in these waters is an ever changing problem. The rapidly increasing population and industrial activity in this area and projected hydraulic developments will necessitate continual supervision of the pollution control program. The adequacy of any new treatment works for both sewage and industrial wastes must be demonstrated. Technical difficulties are anticipated in connection with certain industrial wastes where further development of treatment measures is required.

A spirit of cooperation has been evident, particularly among industries. Such cooperation has also been shown by the municipalities, but it has been less productive largely because of financial difficulties. Many large industrial concerns are undertaking their own pollution research and abatement programs on a national scale. Other industries have formed into groups or associations primarily for the development of waste treatment methods. Such groups include the Manufacturing Chemists Association of the United States, the American Petroleum Institute, the National Council for Stream Improvement (of the Pulp, Paper and Paperboard Industries) Incorporated, The American Iron and Steel Institute, and many others.

Past experience has shown that constant effort and attention by regulatory authorities is needed if existing pollution is controlled and new pollution is to be prevented. It is believed advisable for the Commission to foster pollution abatement programs for the boundary waters through consultation and cooperation with Federal, State and Provincial governments. The administration of such a program should be carried on through existing pollution abatement authorities. Progress in this work will be aided if a committee be established to maintain a continuing interest in the pollution problem. Such a committee would supplement and strengthen the efforts made by local authorities and would permit the interchange of reports on progress. This committee should consist of representatives from the Federal, State and Provincial governments involved in this problem.

DEFINITION OF TERMS

Av.	average.
B. coli or B. coli group	the coli-aerogenes group as used in all editions of Standard Methods of Water Analysis prior to the sixth edition. It is equivalent to the coliform group as defined in later editions of Standard Methods and as used during this investigation.
Board, Board of Sanitary Experts, or Advisory Board	Board of Technical Advisers to the International Joint Commission in the investigations described in this report.
B. O. D.	Biochemical Oxygen Demand.
Boundary Waters	the waters from main shore to main shore between the United States and Canada, as defined in the Treaty of 1909.
Can.	Canada.
c.c.	cubic centimeter.
c.f.s.	cubic feet per second.
Coliform or coliform group	those organisms which will ferment lactose in the presence of brilliant green bile in the proportions contained in standard dehydrated media of that type.
Commission	the International Joint Commission.
f.p.s.	feet per second.
Imp.	Imperial.
International Boundary or boundary	the boundary between the United States and Canada.
median	the value which is equaled or exceeded by exactly half the values in the given list.
L. W. D.	Low Water Datum. Local water level as referred to mean tide at New York City.
M. G. D.	million gallons per day.
Michigan Stream Control Commission	agency replaced by Michigan Water Resources Commission, May 1949.
ml.	milliliters.
M. P. N. or M. P. N. Index	the number of coliform organisms per 100 ml. when calculated from multiple tube dilution tests.
N	Niagara, as used in chapter headings, tables and figures.
No.	number.
P. A.	Public Act.
pH	hydrogen ion concentration.
Phelps Index	the number of B. coli per 100 ml. when calculated from the results of single tube dilution tests.
p.p.b.	parts per billion, by weight.
p.p.m.	parts per million, by weight.
primary or partial treatment	the first major step in sewage treatment works, usually screening, grit removal, and sedimentation.
secondary treatment	the treatment of sewage by biological methods following primary treatment.
Section	the Lake Huron-Lake Erie Section, the Lake Superior-Lake Huron Section or the Lake Erie-Lake Ontario Section of the boundary waters.
seiche	an oscillation of the surface of a lake due to meteorological conditions, with the period of a cycle varying from a few minutes to many hours.
slug or spill	the release of a volume of highly concentrated polluting material over a short period of time.
SM	St. Marys River, as used in chapter headings, tables and figures.
U. S.	United States.
%	percent.

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